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Department of Astrophysical, Planetary
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October 18, 1994

Dr. Patrick Minnis
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Dear Pat:

This is a final report of our research under project "Global Surface-Based Cloud Observation for ISCCP," NASA Grant NAG 1-998, which started on 18 March 1989 and terminated on 30 June 1994. As outlined in our initial proposal, the purpose of the project was to study the surface-based cloud climatology for the years 1983–1988 to help validate the satellite-derived cloud products in ISCCP. The project was later extended to cover the ten-year period 1982–1991 as a continuation of our earlier cloud climatology studies (Warren et al. 1986, 1988) and to take advantage of the lengthened period of ISCCP observations. In addition, we subsequently proposed to reconsider our method of analysis of nighttime cloud reports to correct for a bias due to difficulties of nighttime cloud detection. This correction (moonlight correction) was applied to our analysis of total cloud cover and the frequency of occurrence of clear sky for the period 1982–1991. We also prepared a data set for the global distribution, as derived from all observations, of the frequency of fog and precipitation for the same period. Application of the moonlight correction resulted in an increase of about 2% in the newly computed daily cloud amounts. Use of the moonlight correction also provided patterns of the diurnal cycle of total cloud that were more consistent with those derived from the ISCCP observations.

Although we had originally proposed to complete the surface-based climatology of both total cloud and cloud type amounts, we were only able to finish the analysis for total cloud. We have, however, prepared an archive of total cloud cover and a data set of individual cloud observations, including cloud types, covering the period 1982–1991 to be distributed to the user community by CDIAC.

1. Effect of Moonlight on Cloud Observations at Night

As is known, there is difficulty in surface-based detection of clouds when the sun is significantly below the horizon and there is insufficient moonlight in the nighttime sky. To correct for this situation, we analyzed ten years of nighttime reports (December 1981–November 1991) over the latitude belt 0–50°N to study the variation of reported cloud cover as a function of illumination due to moonlight. We found that the total cloud amount reported at night increased up to a certain threshold after which the reported cloud amount leveled off. This threshold "illuminance criterion" corresponds to the light produced by the twilight sun at a solar altitude of about 9° below the horizon. Thus, the moonlight criterion is met when either the solar altitude is greater than −9° or the position of the moon (e.g., elevation, phase, and distance) is such that its illuminance exceeds the threshold value. Considering that the moon is in the night sky only 50% of the time, application of the moonlight criterion still permits the use of about 38% of the observations made with the sun below the horizon.

2. Global Distribution of Total Cloud Cover (1982–1991)

Using the moonlight criterion, we have analyzed ten years (1982–1991) of worldwide surface weather observations over land and oceans for total cloud cover and for the frequency of occurrence of clear sky, fog, and precipitation. The 'global' distributions of daily total cloud cover for this period are shown in Figures 1a and 1b for averaged December–January–February (DJF) and June–July–August (JJA). Because of the lack of adequate surface observations, the analyses do not extend much beyond 70°N or 50°S. The overall patterns of the total cloud cover are very well known and generally replicate the distributions shown in our earlier cloud atlases given separately for land and oceans (Warren et al. 1986, 1988). On average, there is a northward and southward shift of maximum and minimum cloudiness with the seasons, with larger displacement over land than ocean areas.

The global average cloud cover (average of day and night) is about 2% higher if we impose the moonlight criterion than if we use all nighttime reports. The difference is somewhat greater in the winter than in the summer hemisphere because of the fewer hours of darkness in the summer. This result is consistent when comparison is made between the results shown in Figures 1a and 1b and those published for the land and oceans for the years 1971–1981 (London et al. 1989). At all latitudes, except in polar regions during summer, the average total cloudiness is about 2% higher than given earlier when all nighttime reports were used in the analysis.

The computed diurnal cycles of total cloud cover are altered considerably when the moonlight criterion is imposed. Maximum cloudiness over much of the ocean is now found to be at night or in the morning, whereas in our published atlases without the moonlight criterion the computed maximum was obtained as noon or early afternoon in many regions. The diurnal cycles of total cloud cover we now obtain, when compared with those of ISCCP for a few sample regions, are generally in better agreement if the moonlight criterion is imposed on the surface observations. The average cloud cover is found to be greater during the day than at night by 3.3% over land and by only 0.3% over the ocean. Cloud cover is greater at night than during the day over the open oceans far from the continents, particularly in summer.

Some details of the global distrubution of average day–night differences of observed cloudiness are given in figures 2a and 2b for DJF and JJA. The surface cloud reports were grouped into three-hour intervals, and for convenience, we defined day as 0600–1800 and night as 1800–0600 local time. Since we used three-month averaged data to represent meteorological seasons, the definitions of day and night are approximately correct up to about 70°N/S. The overall pattern is one of dominant daytime total cloud over land and dominant nighttime cloud over ocean for mid to subpolar latitudes of each summer hemisphere. At low latitudes, however, there is a tendency for a higher total cloud amount during the day than during the night, especially over the western sectors of the tropical oceans. This pattern has a strong seasonal shift as the ITCZ moves from the south tropical to the north tropical oceans from DJF to JJA accompanied by displacement of the associated convective systems. Note that at higher latitudes in the Northern Hemisphere total cloud amounts are slightly higher during the day than night over most of the north Atlantic and part of the north Pacific during DJF. But for JJA, the cloud amounts are larger at night. An analagous situation occurs for the Southern Hemisphere oceans. At subpolar latitudes during summer, the predominant nighttime overcast stratus decks become broken during daylight hours. Over some land areas, as for instance the central United States, the Sahara, Saudi Arabia, and Southwest Africa, there is a nighttime maximum of total cloud during the summer months. This occurs because strong local thermal instability in late afternoon continues into the night with a spreading out of the top portion of the convective clouds. This process gives rise to maximum nocturnal thunderstorms in the summer as, for instance, seen in the central U.S. and the other regions.

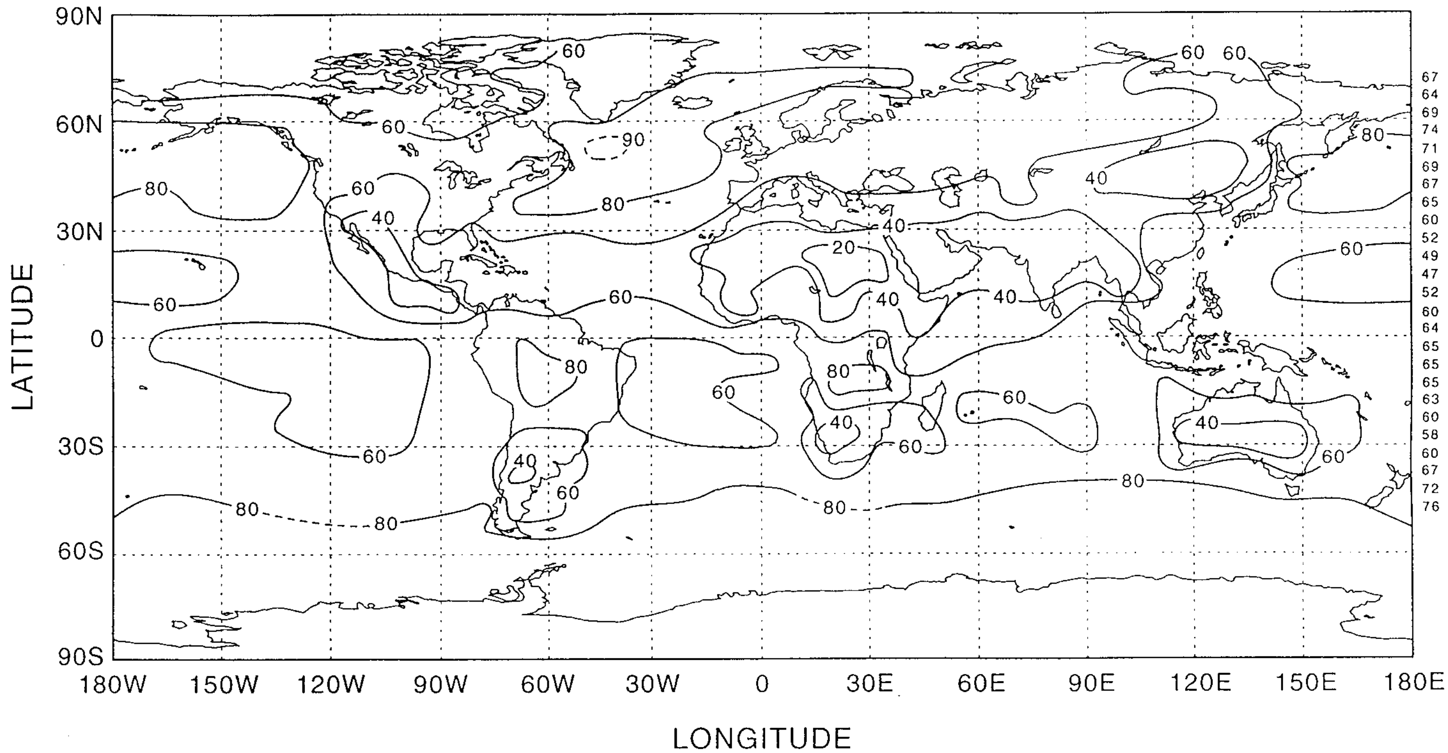

Figure 1a. Global Distribution of Total Cloudiness (%)
Surface Observations (1982-1991) DJF

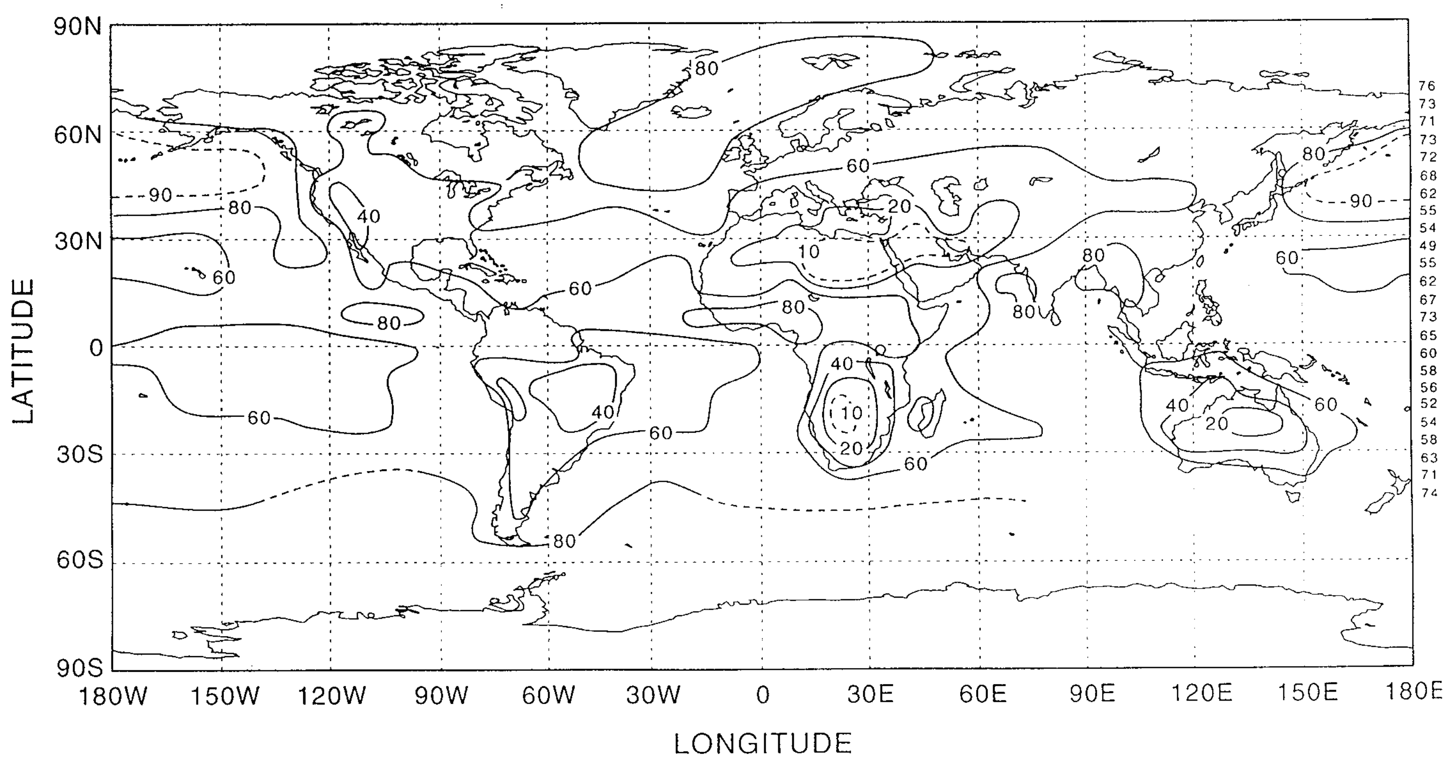

Figure 1b. Global Distribution of Total Cloudiness(%)
Surface Observations (1982-1991) JJA

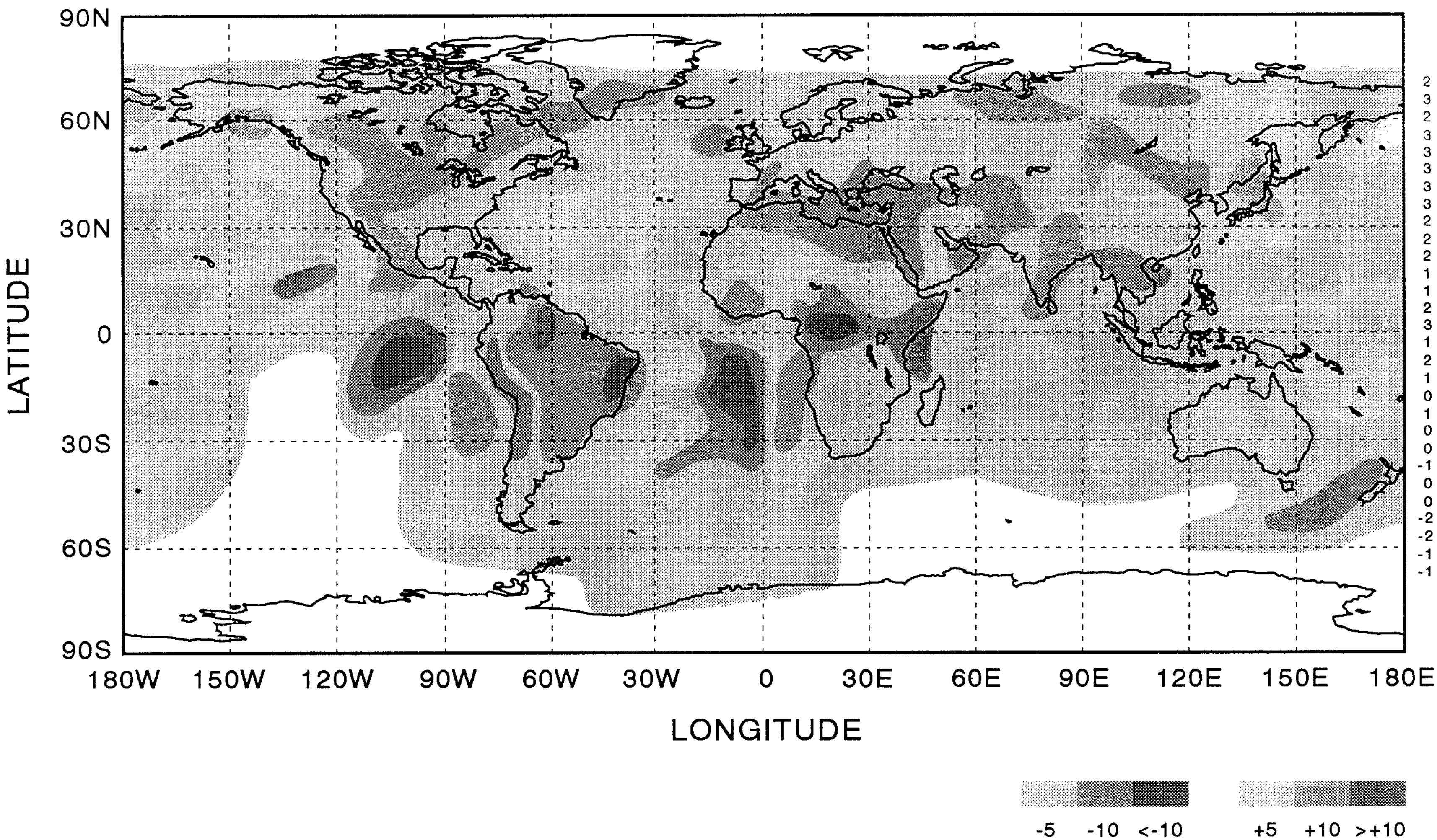

Figure 2a. Surface Observations: Average Differences of Total Cloudiness
Day – Night (1982-1991) DJF

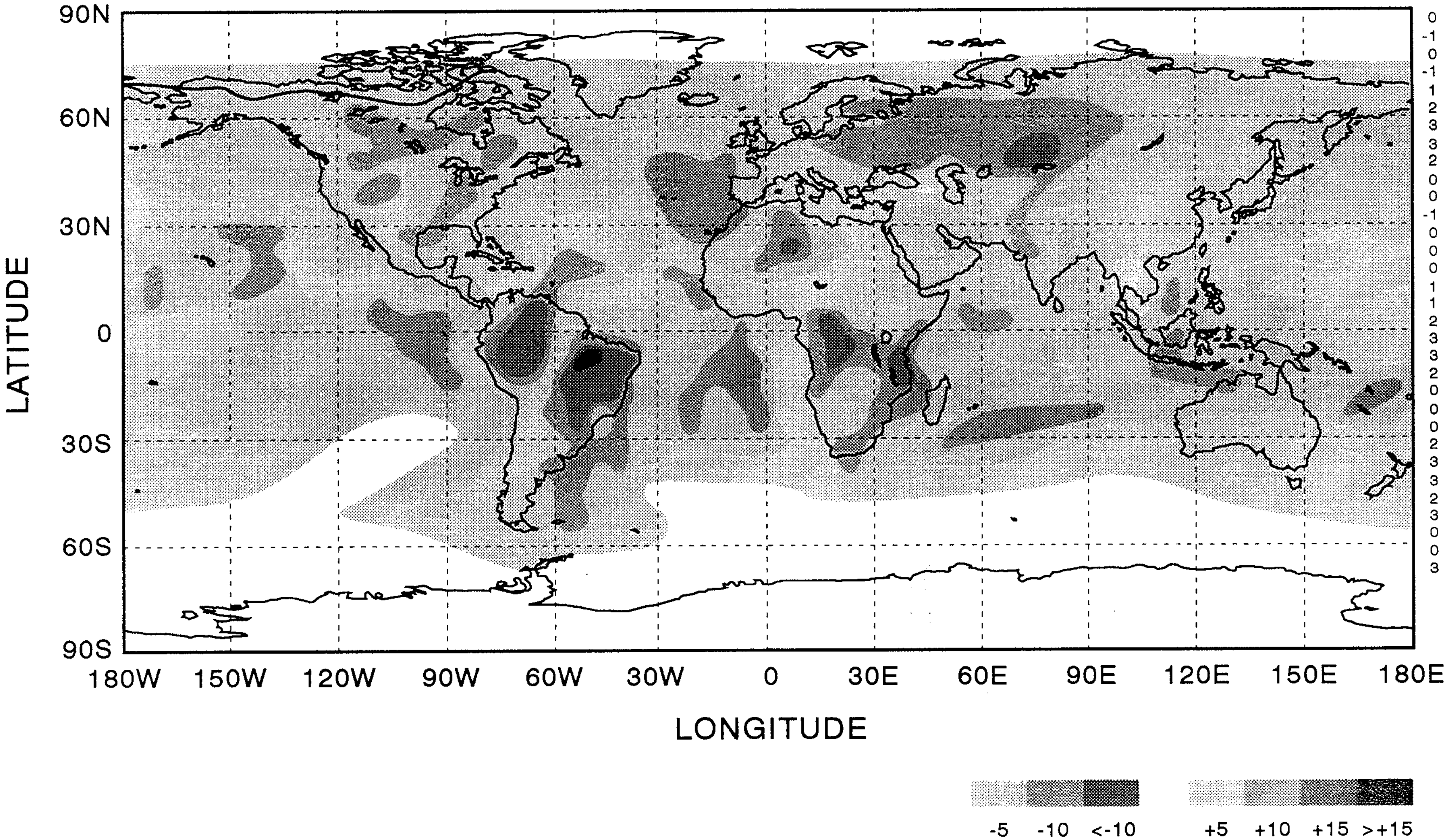

Figure 2b. Surface Observations: Average Differences of Total Cloudiness
Day – Night (1982-1991) JJA

A paper was submitted to the *Journal of Climate* on "The effect of moonlight on observation of cloud cover at night, and application to cloud climatology." The paper has been reviewed, revised, and returned to the journal. A copy of the manuscript is attached here as Appendix A. Some of these results were also presented by Julius London at the AGU meeting in May 1994 and by Stephen Warren at the Aspen Global Change Institute in July 1994. A copy of the abstract for the AGU presentation is also enclosed.

3. Comparisons with ISCCP Observations (1984–1990)

As stated in our original proposal, we had planned to compare the distributions of total cloud and cloud type amounts as reported from ground-based and satellite derived observations covering the common period of available data. We noted above that we were only able to complete our analysis for total cloud. The period of synchronous observations of total cloud for which we could compare the results of these two observational systems cover the interval DJF 1984 to JJA 1990. The difference in total cloud, ISCCP − surface observation, is shown in Figures 3a and 3b for the seasons DJF and JJA.

Overall, surface observations verify the general pattern of cloudiness as derived from the ISCCP data. The difference in cloudiness as reported for the two sets of observations (ISCCP − surface obs) does not generally exceed ±10%. The major exceptions are found at high latitudes in the Northern Hemisphere and north central Africa. There are relatively few high-latitude surface observations in the Southern Hemisphere Winter [JJA], but these few observations do exhibit exceedingly high negative differences. The differences are, by and large, positive over ocean and negative over land areas. This pattern is generally consistent with that reported by Rossow et al. (1993) based on comparisons using a more limited set of satellite data and surface observations for the period 1971–1981 which did not make use of our moonlight corrections. Note that, as mentioned earlier, there are relatively few surface observations in the polar regions during winter. However, sufficient data are available for summer to indicate that the values shown for high latitudes are probably qualitatively correct. It is most likely that these negative differences result from underestimating total cloud as derived by satellites because of the persistence of low stratus clouds over a cold snow-covered base at these latitudes and the difficulty of distinguishing between the two high reflecting and low IR emission surfaces.

Other large disparities in the reported total cloud cover occur over the northwest United States and southwest Africa during winter (negative values) and tropical Indian ocean (positive values) during both seasons. Averaged latitudinal values shown in the right-hand columns of Figures 2a and 2b indicate a tendency towards a northward and southward shift of the differences with season similar to the north-south shift of the latitude averaged total cloud cover shown in Figures 1a and 1b.

4. Archived Analysis

The results of our total cloud cover analysis have been archived for users by DOE-CDIAC (Oak Ridge), and documented in a report to be distributed with the data: *Climatological Data for Clouds over the Globe Surface from Surface Observations, 1982–1991,* Numeric Data Package NDP-026A).

Archived data, consisting of various annual, seasonal, and monthly averages are provided in grid boxes that are typically 2.5° × 2.5° for land and 5° × 5° for ocean. Day and nighttime averages are also given separately for each season. Several derived quantities, such as interannual variations and annual and diurnal harmonics, are provided as well. A copy of the report is attached here as Appendix C.

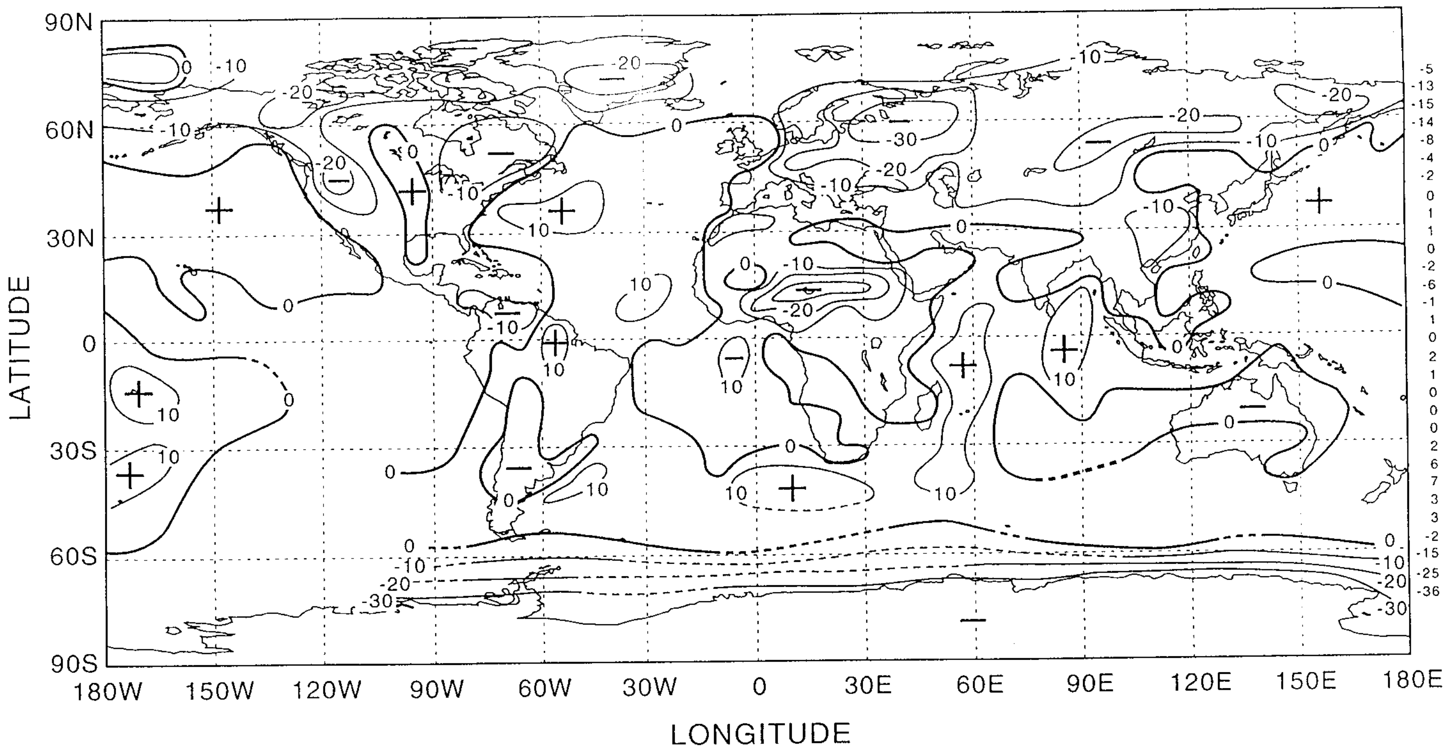

Figure 3a. Differences of Total Cloudiness (%)
ISCCP – Surface Observations (1982-1991) DJF

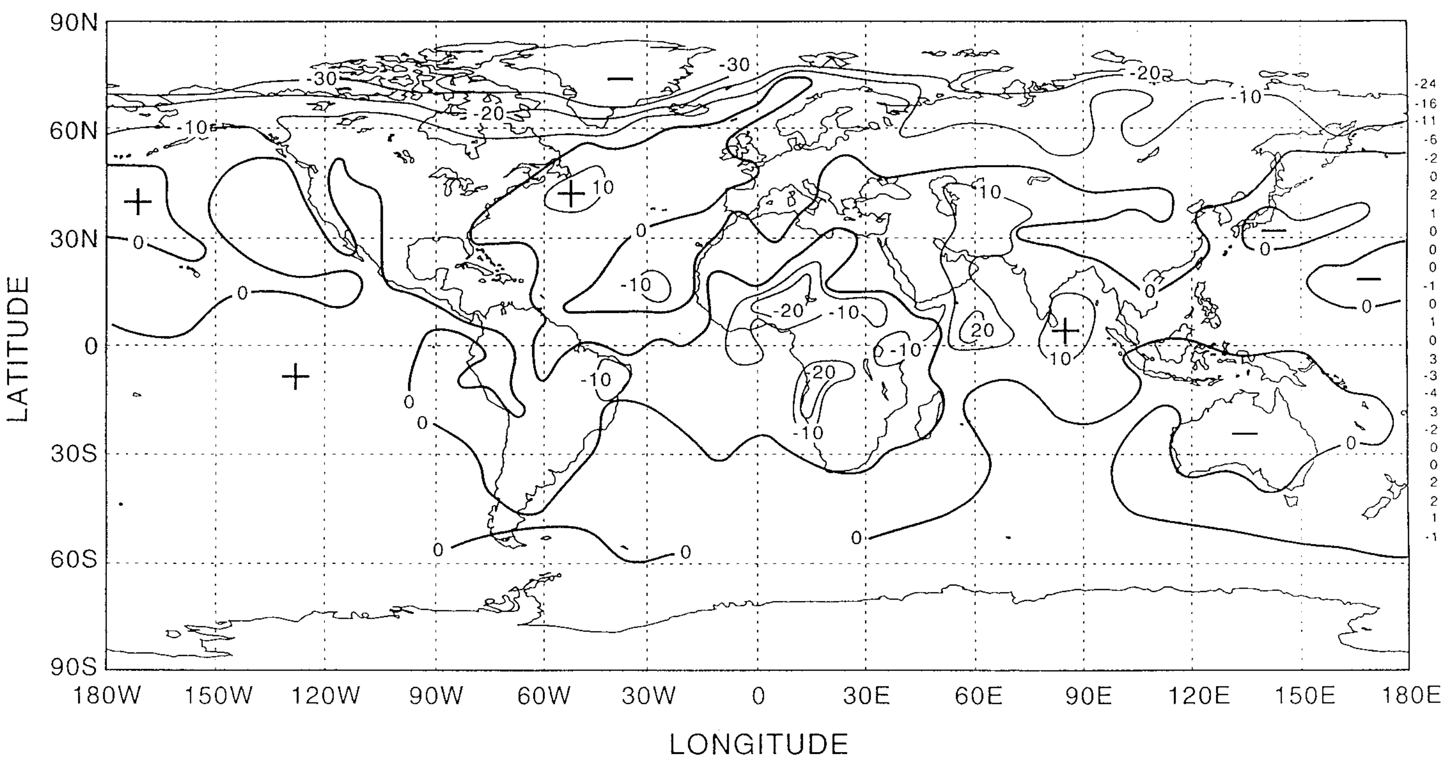

Figure 3b. Differences of Total Cloudiness (%)
ISCCP – Surface Observations (1982-1991) JJA

5. Archive of Edited Cloud Reports

Surface synoptic weather reports for the entire globe, both land and ocean, for the ten-year period from December 1981–November 1991 have been processed, edited, and rewritten to provide a data set designed for use in cloud analyses. The information in these reports relating to clouds, including the present weather information, was extracted and put through a series of quality control checks. Reports not meeting certain quality control standards were rejected. Minor correctable inconsistencies within reports were edited for consistency so that the edited report can be used for cloud analysis without further quality checking. Cases of "sky obscured" were interpreted by reference to the present weather code as to whether they indicated fog, rain, snow, or thunderstorm. Special coding is added to indicate probable nimbostratus clouds which are not specifically coded for in the standard synoptic code. Any changes made to an original report are also noted in the archived edited report so that the original report can be reconstructed if desired. This 56-character "edited cloud report" also includes the amounts, either inferred or directly reported, of low, middle, and high clouds, both overlapped and non-overlapped. Since illumination from the moon is important for the adequate detection of clouds at night, both the relative lunar illuminance and the solar zenith angle are given, as well as an indicator that tells whether our recommended illuminance criterion was satisfied.

With this data set a user can develop a climatology for any particular cloud type, or group of types, for any geographical region and at any spatial and temporal resolution desired. The data set consists of 240 files, one file for each month of data for land and ocean separately. The archive contains 124 million reports from land stations and 15 million reports from ships. The data set is archived by DOE-CDIAC and is to be distributed by them as Numeric Data Package NDP-026B. It is extensively documented in a report: *Edited Synoptic Cloud Reports from Ships and Land Stations over the Globe, 1982–1991.* A copy of the report is attached here as Appendix D. The two documented data sets (NDP-026A and NDP-026B) will also be available from the Data Support Section at NCAR.

Acknowledgements. We would like to acknowledge the helpful support given to this project by the computing facilities at the National Center for Atmospheric Research and, in particular, by Roy Jenne and Dennis Joseph of the Data Support Section at NCAR. Some of the discussions in this final report were summarized in a report to Battelle Pacific Laboratories who also contributed partial support for our tabulation and analysis of the surface-observed cloud data.

References Cited

London, J., S.G. Warren, and C.J. Hahn, The global distribution of observed cloudiness—A contribution to the ISCCP. *Adv. Space Res.*, 9, (7)161–(7)165, 1989.

Rossow, W.B., and L.C. Garder, Cloud detection using satellite measurements of infrared and visible radiances for ISCCP. *Journal of Climate*, 6, p. 2341–2369, 1993.

Warren, S.G., C.J. Hahn, J. London, R.M. Chervin, and R.L. Jenne, *Global Distribution of Total Cloud Cover and Cloud Type Amounts over Land.* NCAR Technical Note, NCAR/TN–273+STR, 229 pp., 1986.

Warren, S.G., C.J. Hahn, J. London, R.M. Chervin, and R.L. Jenne, *Global Distribution of Total Cloud Cover and Cloud Type Amounts over the Ocean.* NCAR Technical Note,

NCAR/TN–317+STR, 201 pp., 1988.

Sincerely,

Julius London
Principal Investigator

cc: Dr. Stephen Warren, co-PI, University of Washington
Dr. Carole Hahn, University of Arizona

Attachments:

Appendix A. Abstract for manuscript submitted to Journal of Climate

Appendix B. AGU Abstract

Appendix C. Documentation for total cloud archive NDP-026A

Appendix D. Documentation for archive of edited cloud reports NDP-026B

Appendix A

The Effect of Moonlight on Observation of Cloud Cover at Night, and Application to Cloud Climatology

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Revised manuscript returned to *Journal of Climate*

October 1994

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ABSTRACT

Visual observations of cloud cover are hindered at night due to inadequate illumination of the clouds. This usually leads to an underestimation of the average cloud cover at night, especially for the amounts of middle and high clouds, in climatologies based on surface observations. The diurnal cycles of cloud amounts, if based on all the surface observations, are therefore in error, but they can be obtained more accurately if the nighttime observations are screened to select those made under sufficient moonlight.

Ten years of nighttime weather observations from the northern hemisphere in December were classified according to the illuminance of moonlight or twilight on the cloud tops, and a threshold level of illuminance was determined, above which the clouds are apparently detected adequately. This threshold corresponds to light from a full moon at an elevation angle of 6^{o} or from a partial moon at higher elevation, or twilight from the sun less than 9^{o} below the horizon. It permits the use of about 38% of the observations made with the sun below the horizon.

The computed diurnal cycles of total cloud cover are altered considerably when this moonlight criterion is imposed. Maximum cloud cover over much of the ocean is now found to be at night or in the morning, whereas computations obtained without benefit of the moonlight criterion, as in our published atlases, showed the time of maximum to be noon or early afternoon in many regions. Cloud cover is greater at night than during the day over the open oceans far from the continents, particularly in summer. However, near-noon maxima are still evident in the coastal regions, so that the global annual average oceanic cloud cover is still slightly greater during the day than at night, by 0.3%. Over land, where daytime maxima are still obtained but with reduced amplitude, average cloud cover is 3.3% greater during the daytime. The diurnal cycles of total cloud cover we obtain are compared with those of ISCCP for a few regions; they are generally in better agreement if the moonlight criterion is imposed on the surface observations.

Using the moonlight criterion, we have analyzed ten years (1982-1991) of surface weather observations over land and ocean, worldwide, for total cloud cover and for the frequency of occurrence of clear sky, fog, and precipitation. The global average cloud cover (average of day and night) is about 2% higher if we impose the moonlight criterion than if we use all observations. The difference is greater in winter than in summer, because of the fewer hours of darkness in summer. The amplitude of the annual cycle of total cloud cover over the Arctic Ocean and at the South Pole is diminished by a few percent when the moonlight criterion is imposed.

The average cloud cover for 1982-1991 is found to be 55% for northern hemisphere land, 53% for southern hemisphere land, 66% for northern hemisphere ocean, and 70% for southern hemisphere ocean, giving a global average of 64%. The global average for daytime is 64.6%; for nighttime 63.3%.

APPENDIX B

Paper presented at the AGU Meeting in May 1994

Differences Between Ten-Year-Averaged Day and Night Surface-Observed Distributions of Total Cloudiness

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ABSTRACT

Clouds represent a principal component of the physical processes affecting radiative forcing in the atmosphere and thus the climate of the earth-atmosphere system. Variations in cloudiness at all time and space scales will modify this radiative forcing. We present analyses of the geographic distribution of day minus night values of surface-observed total cloudiness for the ten-year period 1982–1991. It is shown that, in general, the differences are small over the Northern and most of the Southern Hemisphere oceans during winter but are consistently negative, larger than 5%, over the subtropic and mid latitude regions of the central and eastern parts of the oceans during summer. As is to be expected, the day minus night differences are positive over most continental areas with larger than 10% more day than night cloudiness principally over central Asia and central South America. A comparison of these day minus night differences with a slightly shorter, seven-year, period (1984–1990) of total cloudiness data derived from ISCCP observations is discussed. The data derived from these two different observational modes are too noisy to determine significant time changes of the day minus night differences over these short periods.

APPENDIX C

CLIMATOLOGICAL DATA FOR CLOUDS OVER THE GLOBE FROM SURFACE OBSERVATIONS, 1982-1991: The Total Cloud Edition

(Documentation)

February 1994

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Hahn, C.J., S.G. Warren, and J. London, 1994: *Climatological Data for Clouds Over the Globe from Surface Observations, 1982-1991: The Total Cloud Edition.* NDP026A, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN. (Also available from Data Support Section, National Center for Atmospheric Research, Boulder, CO.)

Abstract:

Routine, surface synoptic weather reports from ships and land stations over the entire globe, for the ten-year period December 1981 through November 1991, were processed for total cloud cover and the frequencies of occurrence of clear sky, precipitation, and sky-obscured due to fog. Archived data, consisting of various annual, seasonal and monthly averages, are provided in grid boxes that are typically $2.5^{\circ} \times 2.5^{\circ}$ for land and $5^{\circ} \times 5^{\circ}$ for ocean. Day and nighttime averages are also given separately for each season. Several derived quantities, such as interannual variations and annual and diurnal harmonics, are provided as well. This data set incorporates an improved representation of nighttime cloudiness by utilizing only those nighttime observations for which the illuminance due to moonlight exceeds a specified threshold. This reduction in the night-detection bias increases the computed global average total cloud cover by about 2%. The impact on computed diurnal cycles is even greater, particularly over the oceans where it is found, in contrast to previous surface-based climatologies, that cloudiness is often greater at night than during the day.

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1. INTRODUCTION

This report describes a data archive that contains global coverage of analyzed cloud data. The cloud data contained in this archive (the "Total Cloud Edition") are for total cloud cover. In addition, the frequencies of occurrence of clear sky, precipitation, and sky-obscured due to fog (collectively referred to here as "weather types") are also included. Analyses of cloud types are not provided here. All data utilized here were obtained from routine, surface synoptic weather reports for the ten-year period December 1981 through November 1991. The specific contents of the archive are described in Section 3. Briefly, the archive contains various annual, seasonal and monthly averages for total cloud and the three weather types in grid boxes that are typically 2.5^{o} x 2.5^{o} for land and 5^{o} x 5^{o} for ocean. Several derived quantities, such as interannual variations and annual and diurnal harmonics, are also provided.

Previously the authors prepared a similar cloud data archive that spanned the years 1930 to 1981 (Hahn et al., 1988). Some of the data contained in that archive were presented in published atlases (Warren et al., 1986, 1988). The present archive represents not only an extension of the time period analyzed, but an improvement in the analysis scheme that results in more reliable estimates of cloudiness at night. This not only leads to more accurate daily averages, but, more significantly, leads to a more reliable determination of diurnal cycles than has been obtained previously from surface observations on a global scale.

2. DATA SOURCE AND ANALYSIS

A. Data Sources

For land stations, synoptic weather reports were obtained from the National Meteorological Center (NMC). Only those stations which have been assigned official station numbers by the World Meteorological Organization (WMO) were utilized. About 124 million reports were available for cloud analysis for the 10-year period December 1981 through November 1982 (referred to as 1982-91). Synoptic reports are recorded 8 times per day: 00, 03, 06, 09, 12, 15, 18, 21 GMT. However, many stations report only every 6 hours (notably those in the United States and Australia), some less often, and some only during the daytime.

Ship reports were obtained from the Comprehensive Ocean-Atmosphere Data Set (COADS), Interim Product CMR5 Reports (Woodruff et al., 1987). There were 14.4 million reports available for cloud analysis over the oceans.

B. Data Analysis

1) Processing of Weather Reports.

Synoptic weather reports are coded according to the system given by the World Meteorological Organization (WMO, 1988). The information in these reports that relates to cloud analysis is summarized in Table 1. For the total cloud and weather type analyses reported here, only N, ww, and I_X are of direct relevance. However, N_h, C_L, C_M and C_H were used in error checking. Definitions of the cloud and weather types analyzed here are given in Table 2.

The flow chart in Figure 1 shows the processing and quality control checks performed on each weather report read from the original archives (NMC or COADS). The percentage of reports discarded at each stage of the processing is indicated. Land and ship reports required slightly different checks in the early stages of processing but were treated identically below the horizontal dashed line in the upper portion of the figure. If a land station did not have a WMO station number it was discarded (many of these were from the United States), thus ensuring more uniformity in reporting procedures. If a ship report was known to be from a buoy (from the "deck" number in the COADS data) it was discarded. Any report that had no cloud information (N=/) was discarded.

In 1982 WMO introduced several coding procedure changes (WMO, 1988). One of these changes now instructs observers to set ww=/ if present weather was either "not available" or "observed phenomena were not of significance" (ww codes 00-03 are considered to represent phenomena without significance). The present weather indicator, I_X, is used to distinguish these cases. Land station reports with I_X values of 4, 5 or 6 signify automatic weather stations and were discarded. Reports with I_X=3 (data not available) were also discarded because without ww it is not possible to interpret cases of N=9 (see Warren et al., 1986) or to evaluate the occurrence of precipitation. I_X=2 indicates that observed phenomena were not of significance, while I_X is coded as "1" when ww is given. Occasionally I_X=1 when ww=/. These inconsistent reports were also discarded.

Examination of the NMC data set showed that while land station reports conformed to this new coding procedure almost immediately, ship reports did not incorporate I_X coding consistently until 1985. The COADS data set does not even contain I_X. Thus some ship reports that should be discarded on the basis of I_X were kept. At the horizontal dashed line in Figure 1 there were 125 million land reports and 15.8 million ship reports remaining. The discard fractions below the line are fractions of these numbers.

If the sky was obscured due to fog (1.1% land, 2.5% ship), thunderstorms (0.05% land, 0.17% ship), or rain/snow (0.4% land, 1.1% ship), the sky was considered to be overcast (N=8). This source of "cloudiness" contributed about 1% to the total cloud cover globally, and much more in some locations and seasons (Hahn et al., 1992).

Other data consistency checks are indicated in the figure. The final one tests whether the reported latitude and longitude of a land station puts the station on water (rare) or whether reported latitude and longitude of a ship puts the ship on land (1.3%). The reports that survive these tests (124.2 million for land and 14.4 million for ships) are used to compute total cloud cover and the frequencies of occurrence of clear sky, fog, and precipitation. Cloud types were not analyzed further in this study.

2) Determination of Cloudiness at Night.

The ability of surface observers to adequately detect clouds at night has been questioned for many years (e.g. Riehl, 1947; Schneider et al., 1989). In an attempt to find a practical solution to this "night-detection-bias", the authors (Hahn et al., 1994) analyzed ten years of nighttime data for the zone 0-50^{0} N and plotted reported cloud cover as a function of the illumination due to moonlight. The illuminance function used by the authors depends on the phase and altitude of the moon and on the distance of the moon from the earth. It was found that the amount of total cloud reported at night increased as the illuminance of the moon increased up to a certain threshold, after which reported cloud amounts leveled off. This threshold is referred to as "the illuminance criterion" and corresponds to the light produced by the twilight sun at an altitude of about 9 degrees below the horizon. Thus the illuminance criterion is met when either the sun is at an altitude greater than -9^{o} or the position of the moon is such that its illuminance exceeds the threshold. These conditions can be determined for each report with the use of an ephemeris and the latitude, longitude, and time of the report.

By using only reports for which the illuminance of the moon (or sun) exceeded the threshold illuminance, we can obtain more reliable estimates of nighttime cloudiness than have been previously obtained from surface observations. Application of the illuminance criterion increases the computed global average total cloudiness at night by about 4% and thus increases the daily average cloudiness by about 2%. There is also a significant effect on computed diurnal cycles which will be demonstrated in Section 3.

This illuminance criterion was applied in the analyses of total cloud cover and clear-sky frequency archived here, but not for fog and precipitation whose detection does not depend on illumination. (For comparative purposes, some analyses of total cloud and clear sky were also performed utilizing all observations as described in Section 3.) Application of the illuminance criterion caused 27% of the land reports and 24% of the ship reports to be discarded, leaving 90.4 million reports for land and 10.9 million reports from ships.

3) Averaging Methods.

An average for a synoptic hour, or for daytime or nighttime only, was obtained simply by averaging all the contributing reports, whether for a single year or a multi-year average. Because many nighttime reports are discarded due to the illuminance criterion, there are far fewer contributing reports at night than during the daytime. Therefore, to obtain the "daily" average, daytime and nighttime averages are first determined separately and then averaged together. For this purpose, daytime is considered to be 06-18 local time (determined from the longitude at the center of the grid box in which the observation was made) and nighttime is considered to be 18-06 local time. A daily average was obtained by this method if there were at least 50 observations contributing to both the day- and nighttime averages. If there were less than 50 observations at night (day) but 100 or more for the daytime (night), then only the daytime (nighttime) observations were used for the average. Otherwise averages were obtained by using all available observations, regardless of time of day. This method was applied uniformly over the globe, even though the method loses significance near the poles. (The poles themselves were considered to be on Greenwich Mean Time.) The particular method used in computing an average is coded in the data record which is described in Section 3.

It should be noted that in a single month at a single point on earth the moon will be above the horizon at night only for about 2 weeks. Thus a nighttime average for a single month, when the illuminance criterion has been applied, will not be fully representative of that month. Longer term averages will be statistically more reliable. For this reason, monthly mean daily averages are not provided in this data archive, although the data for obtaining them are available in the "monthly means by synoptic hour" that are provided (Section 3).

C. Grid Sizes

The globe was divided into grid boxes for which the various cloud quantities were computed. The three grid sizes used in these analyses are, nominally: $2.5^{\circ} \times 2.5^{\circ}$, $5^{\circ} \times 5^{\circ}$, and $10^{\circ} \times 20^{\circ}$ latitude x longitude. Because the area contained within a $5\text{x}5^{\circ}$ box, for example, decreases with increasing latitude, boxes poleward of 50° latitude were made to encompass a wider longitude range such as $5\text{x}10^{\circ}$ or $5\text{x}20^{\circ}$, etc. A "c" is used to symbolize this condensation or contraction. Thus 5x5c (or 5c for short) means $5\text{x}5^{\circ}$ between 50N and

50S but a larger longitude width poleward of 50° latitude. The three grid sizes used are described in Table 3.

Each grid box is assigned a number. The numbering goes from west to east (beginning with the Greenwich Meridian) and north to south. The west and south borders of a box are considered to be within the box (90°N is also considered to be within box 1). The latitude and longitude at the center of each numbered box for each grid are given in this archive (Section 3).

The 5c grid is used for most analyses over the ocean and for some land analyses. The 10c grid is used for some ocean analyses because relatively sparse ocean data make some analyses at the smaller grid size unreliable. The 2c grid is used only for analyses over land where finer resolution is practical.

3. CONTENTS AND ORGANIZATION OF THE DATA ARCHIVE

A. General

The data are divided into 15 files, numbered 2 to 16 as shown in Table 4. File 1 is a brief documentation of the archive, containing excerpts from this report. The organization of data into files is based on similarity of content and data format. Total cloud data are generally separated from weather type data. Land and ocean data are generally in separate files as well. There are many grid boxes that contain both land and ocean, and two separate values are retained in this way. The user can combine the two if desired, although land and ocean values are given at different grid scales making suitable averaging necessary. File 3 contains land and ocean data merged on a 5c grid for selected long-term averages (see below). The files listed with the same group cluster name would logically belong within the same file. However, monthly averages by synoptic hour require so much storage space that they are placed in separate files.

A detailed breakdown of the contents of each data file is given in Table 5. Each data file contains a series of "map groups", each of which consists of gridded data for total cloud or weather type averages for a particular season or year or time of day or for grid information (File 2) as indicated in the table. A map group is made up of the data records for a number of grid boxes over the globe and a header record which identifies the group:

Header record identifying map group
    Data record for first reported box
    Data record for second reported box
    etc. for number of boxes specified in header.

This pattern is repeated throughout each file in the order indicated in Table 5. Data record formats shown in Table 6 and the header record described in Table 7 are discussed in the next section.

The number of data records within a map group depends on the grid size and whether it is for land or ocean. Since there would be no land data in an ocean-only grid box (and vice versa), data records for such boxes are uniformly not written. (Box numbers based on the full grid are provided in the data record itself.) The numbers of boxes given within each type of map group are listed in a footnote to Table 5 (and are coded in the header record). Thus, in File 6, for example, each ocean 5c map group contains 1494 logical records - a header record and 1493 data records, while a land 5c map group in File 4 contains a total of 862 logical records. While there are actually 934 5c boxes with land fractions greater than 0.0001 (and 27 additional boxes with reporting stations on small islands), only 861 boxes have data for the period analyzed here and only those boxes are archived. Similarly there are 3027 2c boxes with land fractions >0.0001 (and 48 additional boxes with reporting stations on small islands) but only 2309 boxes have data. The 10c grid contains so few boxes that it is convenient to retain all 230 boxes, including the 16 land-only boxes. In file 3, where land and ocean are combined on a 5c grid, all 1820 boxes are retained.

B. Details of Organization

The use of Table 5, along with Tables 6 and 7, should enable the user to find any desired quantity, once a few conventions are understood. Abbreviations used are listed alphabetically in Table 8.

1) Map Groups and Data Formats.

Each data file shown in Table 5 is a series of map groups which are numbered consecutively within each group cluster. Each group contains the data relevant to the cloud or weather type quantities listed under the contents heading. These data are given for each reported grid box according to the indicated data format which is described in Table 6. For example, group 2 in File 6 contains data relevant to mean seasonal (DJF, 1982-91) total cloud cover over ocean on a 5c grid. These data are organized according to format 22. Table 6 shows that format 22 specifies the box number, the number of observations, the average amount of total cloud (given to hundredths of a percent), the standard deviation of the observations contributing to the average (given to tenths of a percent), an indicator telling whether contributing observations were from daytime, nighttime, or both (see IDN in Table 8), an indicator telling whether the observations were from land stations or ships, and the number of seasons contributing to the average (relevant only for annual averages).

Data format numbers are given as 2-digit integers. The tens digit distinguishes 5 data classes as shown in Table 6. The units digit is used to distinguish some small difference in the meaning of a variable represented. Format 40 is used to distinguish the fact that the phase of the annual harmonic is given in units of months as opposed to hour for the diurnal harmonic in formats 41 and 42. The differences between formats 41 and 42 (as well as 51 and 52) are simply that the data variables refer to amount or frequency, respectively. While these distinctions (and that between formats 22 and 32) are not essential in this "Total Cloud Edition", these numbers are retained to be consistent with our previous archive (Hahn et al., 1988) and a possible future archive containing cloud type data.

The order in which the groups follow each other, with respect to season, time of day, year or weather type, can also be determined from Table 5. Where there are simply 4 seasons (or 12 months) as with File 4 groups 2-5 (or 42-53), all the boxes for the first season (or month) are followed by the next group header and all the boxes for the second season (or month) and so on. The order in which the seasons are given is DJF, MAM, JJA, SON; months are given in the order Dec, Jan, Feb, · · · Nov. In cases such as for File 4 groups 10-41 or 98-137 where more than one time or year is given for each season, the convention adopted is to increment the parameter listed first while holding the parameter listed second constant. Thus the order for groups 10-41 would be 8 synoptic hours (in order of increasing hour) for DJF, then 8 synoptic hours for MAM, etc. The order for groups 98-137 would be 4 seasons for 1982, 4 seasons for 1983, etc. Thus the individual seasons follow each other chronologically. The order in which weather type groups (as in File 8) follow each other is the numerical order of the numeric codes shown in Table 7. Using the convention of incrementing the leftmost group parameter first, it can be determined, for example, that the group number for precipitation frequency over land for MAM 1982-91 at 03 GMT is 69.

2) Group Headers.

The first record in each map group is a header record which identifies the group. The format of this header record is shown in Table 7. The first parameter of the header record gives the map group number. These numbers have no special significance other than that they run sequentially through a group cluster (Tables 4 and 5) and may aid in locating or identifying a map group.

The next three parameters specify the number of boxes reported in the group (the number of records to be read before reaching the next map group; this number may be less than the total number of boxes in a grid as discussed above), the grid size of the boxes, and whether the data are for land or ocean or both. This latter parameter, LO, differs from the parameter

LOB in Table 6 in that LO specifies the *intent* of the map group while LOB indicates the *actual* condition for a particular box.

The IMOON parameter indicates whether the illuminance criterion was applied in the analysis of the data for the group. The last 5 parameters in the group header indicate the year, season (or month), time of day, cloud or weather type to which the data refer, and the data format.

Even without the map group number, the other 9 parameters together uniquely define each map group. The map group headers, along with example data records, that correspond to the examples given in the last section from Files 6 and 8 are:

```
   21493 520829141-1 122                692309 211829142 3 332
       1 {first data record}                24 {first data record}
       |                                     |
     381  5182 7435 297 32-9              1444    50  200   -9 21-9
       |                                     |
    1809 {last data record}               7290 {last data record}.
```

The first example is for daily-average total cloud cover over the ocean with the illuminance criterion applied for DJF, 1982-91. There are 1493 data records in this 5c map group. The first data record is for box 1 and the last is for box 1809. The example box 381 (in the eastern North Pacific) has 5182 observations with an average of 74.35% total cloud cover. The standard deviation of the observations is 29.7%. The daily average was obtained by averaging daytime and nighttime averages. Only ship data contributed. The "-9" signifies that no value is reported for the last variable, NSN (see below).

The second example is for the frequency of occurrence of precipitation over land at 03 GMT for MAM, 1982-91. The illuminance criterion was not applied. There are 2309 data records in this 2c map group. The first data record is for box 24 and the last is for box 7290. The example box 1444 (in the western United States) had only 50 observations during this time, giving an average precipitation frequency of 2.00%. The standard deviation is not given. These data are for nighttime over land.

C. Details of Contents

All data on this tape were written as integers. Floating point quantities were multiplied by a power of 10 and rounded off to give an integer. When read using the specified formats shown in Table 6, the proper floating point values are recovered. This was demonstrated with the examples given in the last section. Cloud cover and frequencies are given as percent. These and the units of other variables defined in the data formats are defined in Table 8.

After discussing the missing value code, details or peculiarities of the contents of each data file will be discussed. Refer to Tables 5, 6 and 7 for references to file contents, format numbers and header coding, respectively. Any non-standard terms not defined in the text can be found in Tables 1, 2, 3 or 8.

1) The Missing Value Code.

Any data variable for which no value is reported is assigned the "missing value code", which was chosen to be -9. Thus, when reading in the various floating point notations, the actual value obtained may vary but will always be less than 0. The trend (File 16, formats 51 & 52) is the only data variable for which a negative value is valid. Thus for trends the missing value code should be considered to be NYRS=0. Note that any time NOBS is zero, data variables such as AMT, FQ or SD will be assigned the missing value code, but it is possible for data variables, such as SD, to be assigned the missing value code even when NOBS is not zero.

2) File 2: Grid Information; format 10.

The three groups in this file contain data related to the grids used for dividing the globe (see Table 3). The parameters YEAR, SN, TIME and TYPE in the group header are set to -9. Inclusion of the box number in this data format is redundant since here all boxes are reported and data records are in box number order. The latitude (90 to -90 for N to S) and longitude (0 to 360E) of a box center are given to two decimal places. Since the gridded data in all subsequent files are identified only by box number, the information here allows those data to be located on a map. The inverse relation (converting latitude and longitude to box number) can be achieved with a simple mathematical relationship (Hahn et al., 1988). The fraction of each grid box that is land is given to four decimal places. Here "land" means "not ocean" since lakes and ice shelves are counted as land. The method for determining these fractions and a map for the 5c grid are given in Warren et al. (1986). Ocean fraction is 1 - land fraction.

The number of land stations in a 2c box was approximated by taking the number of observations over the 10-year period for a single season (MAM) for either 00 or 12Z, whichever was daytime for a box, and dividing by 10 (for the number of years) and by 3 (for the number of months in a season) to get the average number of reports per month at a single reporting time. If each station always reported, there should then be 30 reports per station. Since station reports are sometimes missing, the above number was divided by 25 to obtain an approximate value for the number of stations. This number may be of value in estimating the reliability or representativeness of data within a box. NLSTA is set to -9 in the 5c and 10c data records.

3) File 3: Land and Ocean Combined; formats 22,32.

This is the only file in which land and ocean values were merged onto a single grid, and this was done only for 10-year mean values (monthly, seasonal and annual). An average (total cloud cover or weather type frequency), for any grid box for which both land and ocean values contributed, was determined by weighting the contributing land and ocean values by their respective fractional area within the box. Only averages made from 100 or more observations were allowed to contribute. The variables SD and IDN (and NSN for seasonal and monthly averages) were set to -9 in the data record. LOB indicates whether land, ocean, both or neither contributed to the box. For the annual averages, NSN is the sum of the number of seasons that contributed to the land and ocean annual averages before merging, and so can have values 0 to 8 (in this file, -9 is used rather than 0). If NSN is 3 to 7 and LOB is 3, it cannot be known how many seasons were contributed by land or ocean without examining the annual map groups for land and ocean separately in their respective files.

NOBS is the sum of the number of observations contributed by land and ocean. For annual averages on a 5c grid, it is possible for NOBS to be greater than 999999 (the maximum allowed in the I6 format) since some boxes, notably in Europe, have a large number of land stations. NOBS in such cases was set to 999999. (The actual number can be retrieved, if desired, by adding up the number of observations in the contributing boxes and seasons given in the other files.)

Figures 2-5 are provided to illustrate some of the information available in this archive and serve as examples against which user output can be checked. The first map group of File 3 contains the data for the global distribution of annual average total cloud cover for the 1982-91 period with the illuminance criterion applied. This is shown in Figure 2a. The global distribution of annual average precipitation frequency (from all observations), a quantity not provided in our previous archive, is given in Figure 2b. These data are contained in map group 3 of File 3. Values are printed in these two figures only where there are at least 100 observations contributing.

4) Files 4-7: Total Cloud Cover; format 22.

Total cloud cover is given in percent (AMT in format 22). Ten-year means for daily average annual, seasonal and monthly total cloud cover are given on the 2c grid for land and on the 5c grid for ocean. Daytime means are given seasonally as well. Because some parts of the southern oceans are poorly sampled (see, for example, Figure 2a), mean seasonal values over the ocean are also given on the 10c grid. It is the 10c grid that is used for the ocean mean seasonal averages by synoptic hour, which are utilized in the diurnal cycle analysis given in File 16. Since land stations are at fixed locations, use of a smaller grid size does not pose the problem that it does for the ocean.

Since previous climatologies, such as our own (Warren et al., 1986; 1988), did not utilize the illuminance criterion, a discontinuity of about 2% would occur when comparing the present with the previous data. Therefore 10-year mean seasonal and yearly seasonal mean values were also computed using all observations (File 4 map groups 54-97 and File 6 map groups 58-101). These data also make it possible to analyze the effects of the illuminance criterion in the present data set. Grid sizes of 5c and 10c for land and ocean, respectively, were selected for ease of comparison with our previous data set (Hahn et al., 1988).

Seasonal means are given for daytime and nighttime values as well as for the daily averages to aid in analysis of possible differences in trends between day and night. Seasonal means for land are given at 5c as well as 2c to make merging with ocean values easier if desired.

The most basic units provided in this data set are the monthly means by synoptic hour. From these, all other averages given, and some not given, can be reconstructed. Since it requires 960 map groups for 10 years of 8 synoptic hours monthly, this unit is provided in a file separate from the rest of the group cluster. The IDN variable in the data record labels each GMT synoptic hour for each box as day or night.

The mean annual total cloud for a grid box was computed by averaging the mean seasonal values of the seasons with 100 or more observations. The number of seasons contributing to the annual average is entered in the NSN variable and may vary from 0 to 4. Note that if NSN is 1, as may be true for ocean boxes near the poles, the reported value may not be representative of the true annual value. NOBS is the sum of the number of observations in the contributing seasons. SD and IDN are set to -9. For seasonal and monthly averages, only NSN was uniformly set to -9.

5) Files 8-15: Weather Types; format 32.

Most of the comments made in the last section apply equally well here. A few differences are noted. Percent frequencies of occurrence of clear sky, precipitation and fog are given in these files. The SD variable in the data record is assigned the missing value code. Precipitation and fog are always computed from all observations and so do not have to be repeated in the "all" map groups. However, since fog is given on the 2c grid for land, it is repeated at 5c for ease of comparison with previous data sets. Daytime and nighttime seasonal means are not given here (but could be reconstructed from the monthly means by synoptic hour if desired). This is also true for seasonal means at 5c for land. Seasonal means for the ocean are given on the 10c grid.

6) File 16: Harmonics, Interannual Variations and Trends; formats 40-42, 51-52.

The unifying feature of the contents of this file is that these are quantities derived from data already given in the archive. Separate land and ocean values are included and two different format types are used to accommodate the harmonic analyses on the one hand and the interannual variations on the other.

The phase and amplitude of the annual harmonic of total cloud cover (or of the frequency of occurrence of a weather type) were computed from the mean monthly values if all 12 months had 100 or more observations. (NT in format 40 always gives the number of months with 100 observations but the other variables were only computed if NT=12.) The amplitude reported is the absolute amplitude so that, for example, if the mean value for a particular cloud amount is 25% and the maximum of the fitted cycle is 30% then the amplitude is reported as 5% (rather than 20% which would be the normalized amplitude). The phase is a numeric value that corresponds to a month such that 1.0 is the middle of January, 2.0 is the middle of February, etc. Phase values reported range from 0.5 to less than 12.5. The value 0.0 (rather than -9) was used for PHASE in cases in which the amplitude was exactly zero (thus distinguishing these from "missing value" cases). AVG is the average of the 12 months used in the analysis and may differ somewhat from the annual values given in the other files because of the different averaging methods. VAF is the percent of the variance accounted for by the amplitude of the annual harmonic.

To exemplify some features of the annual harmonic, figures 3a-c give the geographic distribution of the phase of the annual harmonic for total cloud cover, precipitation frequency and fog frequency, respectively, from the ocean map groups 21, 23 and 24 of File 16. (A phase of "0", common for fog in Figure 3c, indicates that the amplitude is exactly zero.) It is interesting to note that maximum total cloud cover occurs during the summer months in the North Pacific (Figure 3a), while precipitation frequency reaches maximum values during the winter months (Figure 3b). Figure 3c shows that fog is at a maximum in this region during the summer. The amplitude of the annual cycle for fog (available in the data record but not shown here) reaches 10-20% in the western North Pacific, making a significant contribution to the computed total cloud cover in this region during the summer.

By comparison, amplitudes for the fog annual cycle are generally near zero between 30N and 50S over the ocean.

The diurnal harmonic (formats 41-42) was computed from the mean seasonal by-synoptic-hour values if there were 8 or 4 evenly spaced hours with 100 or more observations. If these conditions were met then NT= 8 or 4, otherwise NT was set to 0 and the other variables were set to -9. The amplitude reported is the absolute amplitude (not the normalized amplitude). The phase is the hour of day (mean solar time of the box center) and may range from 0 to less than 24. Since zero is a valid phase here, PHASE was set to -9 for cases in which the amplitude was exactly zero. AVG is the average of the 8 or 4 hours used in the analysis and may differ somewhat from the seasonal values given in the other files because of the different averaging methods. VAF is the percent of the variance accounted for by the amplitude of the diurnal harmonic.

As might be expected, the utilization of the illuminance criterion had a profound effect on the outcome of the diurnal cycle analysis. The geographic distribution of the amplitude and phase of the diurnal harmonic for total cloud cover over the oceans is shown on a 10c grid between 60N and 60S for four seasons in Figures 4a-d. (The phase is printed in these figures only where the amplitude is not zero.) The effect of the illuminance criterion is apparent when comparing these figures to Maps 114-115 of Warren et al. (1988) which show near-noon phases dominating in the diurnal analysis presented for 1954-1983 data without application of the illuminance criterion. For example, for JJA, in Figure 4c, a band of midnight to 5 AM phases evident in the eastern Pacific replaces 4 AM to early afternoon phases in that same region shown in Map 115b of Warren et al. Early afternoon phases are still evident in the western North Pacific and the western North Atlantic, however.

Diurnal cycle analysis for land data is given on the 2c grid. Since it is difficult to display the entire 2c grid, examples are given for two selected mid-latitude regions in Figure 5. Figure 5a shows the diurnal cycle of total cloud cover for part of Asia for DJF. Here diurnal sampling tends to be 8 times per day and there tend to be many reporting stations, particularly in China in the southeast portion of the region. While phase differences between these data and those of Warren et al. (1986, Maps 18-19) tend not to be as dramatic as those over the ocean, the morning phases on the northwest and southeast portions of Figure 5a contrast with those of Warren et al. Where the phases are comparable (and near noon), however, the amplitudes tend to be smaller when the illuminance criterion is applied.

Figure 5b shows the diurnal cycle analysis for JJA for the region of North America that covers most of the United States, where diurnal sampling tends to be 4 times per day. In the eastern portion of the region phases tend to have early afternoon values, in agreement with those of Warren et al. (1986, Maps 22-23), while in the western portion the phases are more variable. This illustrates another feature of the present data set. The $2.5x2.5^{o}$ resolution is capable of resolving features that are missed at $5x5^{o}$, such as the band of late night to early morning phases evident in the central plains of the United States.

The last map groups in this file contain the results of the analysis of interannual variations and trends. For each season, an individual year contributed to the computation of IAV, TRND and UNC (formats 51-52) for a grid box if there were at least 100 observations. The number of years contributing is given in the variable NYRS. SPAN gives the number of years between the first and last years contributing, including the first and last years. If NYRS (also SPAN) is zero, IAV, TRND and UNC are assigned the value -9. IAV is the standard deviation of the contributing yearly values about the multi-year mean. TRND is the slope of the straight line which was fit to the data points by least-squares analysis and is given in units of percent cloud amount (or percent frequency) per year. UNC is the uncertainty of the slope (Bevington, 1969, page 113) in the same units.

4. HOW TO OBTAIN THE DATA

This documentation and the data described herein are available from:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, TN 37831-6335, U.S.A.
Telephone (615) 574-0390

or

Data Support Section
National Center for Atmospheric Research
Boulder, CO 80307, U.S.A.
Telephone (303) 497-1215.

The following citation should be used for referencing this archive and/or this documentation report:

Hahn, C.J., S.G. Warren, and J. London, 1994: *Climatological Data for Clouds Over the Globe from Surface Observations, 1982-1991: The Total Cloud Edition.* NDP026A, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN. (Also available from Data Support Section, National Center for Atmospheric Research, Boulder, CO.)

Note that the archive of our earlier climatology (Hahn et al., 1988), along with accompanying atlases (Warren et al., 1986, 1988), is available from the same sources listed above.

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Table 1. Cloud Information Contained in Synoptic Weather Reports

Symbol	Meaning	Codes*
N	total cloud cover	0-8 eighths 9= sky obscured
N_h	lower cloud cover	0-8 eights
h	lower cloud base height	0-9
C_L	low cloud type	0-9
C_M	middle cloud type	0-9
C_H	high cloud type	0-9
ww	present weather	00-99
I_X	present weather indicator	1-6

* Any category for which information is lacking to the observer is coded as "/".

Table 2. Cloud and Weather Type Definitions Used in Total Cloud Edition

Shorthand notation	Meaning	Synoptic codes
Tcc	Total cloud cover	N= 0-9
Clr	Clear sky	N=0
Ppt	Precipitation	ww= 50-75,77,79,80-99
(R)	rain or snow	50-75,77,79
(T)	thunderstorm	80-99
Fog (F)	Sky obscured due to fog	N=9 with ww= 10-12 or 40-49

Table 3. Grid Box Sizes

Box size (shorthand)	Dimensions lat x lon degrees	Latitude range	Number of boxes in zone	globe
2.5x2.5c				7290
(2c)	2.5x2.5	50N to 50S	144	
	2.5x5	50 to 70	72	
	2.5x10	70 to 80	36	
	2.5x20	80 to 85	18	
	2.5x40	85 to 87.5	8	
	2.5x360	87.5 to 90	1	
5x5c				1820
(5c)	5x5	50N to 50S	72	
	5x10	50 to 70	36	
	5x20	70 to 80	18	
	5x40	80 to 85	9	
	5x360	85 to 90	1	
10x20c				230
(10c)	10x20	50N to 50S	18	
	10x40	50 to 70	9	
	10x60	70 to 80	6	
	10x360	80 to 90	1	

Table 4. File Information (Total Cloud Edition)

File	Group cluster name	General contents	Logical records	Characters per record	Characters
1	RDME	README (brief documentation)	452	80	36,160
2	LLFR	Latitude, Longitude, Land-fraction & Number of land stations for grid boxes	9,343	24	224,232
3	TWLO	Land & Ocean Combined total cloud & weather types	123,828	"	2,971,872
4	TCCL	Land Total Cloud Cover	472,038	"	11,328,912
5	TCCL	Land Total Cloud Cover by synoptic hour, monthly	2,217,600	"	53,222,400
6	TCCO	Ocean Total Cloud Cover	229,134	"	5,499,216
7	TCCO	Ocean Total Cloud Cover by synoptic hour, monthly	1,434,240	"	34,421,760
8	WXTL	Land Weather Types	720,346	"	17,288,304
9	WXTL	Land Clear-sky Frequency by synoptic hour, monthly	2,217,600	"	53,222,400
10	WXTL	Land Precipitation Frequency by synoptic hour, monthly	2,217,600	"	53,222,400
11	WXTL	Land Fog(sky-obscured) Freq. by synoptic hour, monthly	2,217,600	"	53,222,400
12	WXTO	Ocean Weather Types	156,954	"	3,766,896
13	WXTO	Ocean Clear-sky Frequency by synoptic hour, monthly	1,434,240	"	34,421,760
14	WXTO	Ocean Precipitation Freq. by synoptic hour, monthly	1,434,240	"	34,421,760
15	WXTO	Ocean Fog(sky-obscured) Freq. by synoptic hour, monthly	1,434,240	"	34,421,760
16	HIAV	Harmonics & Interannual Variation, land and ocean, total cloud & weather types	96,528	"	2,316,672

Table 5. Data Organization
Contents of Surface-based Cloud Climatology Archive, 1982-1991#
Total Cloud Edition##

File	Number of map groups	Map group numbers	Contents (coded in group header, Table 7)	grid*	groups**	Data format (Table 6)
1			README			text
2-16	9003					
2	3	1-3	GRID LAT,LON,LAND FRACTION, NUM. LAND STATIONS			
	1	1	1820 5x5c boxes			10
	1	2	230 10x20c boxes			10
	1	3	7290 2.5x2.5c boxes			10
3	68	1-68	LAND+OCEAN			
	1	1	Mean Annual TC	5c	1ann	22
	3	2-4	Mean Annual WT	"	1ann,3types	32
	4	5-8	Mean Seasonal TC	"	4sns	22
	12	9-20	Mean Seasonal WT	"	4sns,3types	32
	12	21-32	Mean Monthly TC	"	12mns	22
	36	33-68	Mean Monthly WT	"	12mns,3types	32
4	1217	1-1217	LAND TOTAL CLOUD			
	1	1	Mean Annual	2c	1ann	22
	4	2-5	Mean Seasonal	"	4sns	22
	4	6-9	daytime	"	4sns	22
	32	10-41	by synoptic hour	"	8hrs,4sns	22
	12	42-53	Mean Monthly	"	12mns	22
	4	54-57	Mean Seasonal (all)	5c	4sns	22
	40	58-97	Seasonal Means(all)	"	4sns,10yrs	22
	40	98-137	Seasonal Means	"	4sns,10yrs	22
	40	138-177	Seasonal Means	2c	4sns,10yrs	22
	40	178-217	daytime	"	4sns,10yrs	22
	40	218-257	nighttime	"	4sns,10yrs	22
			Monthly means			
5	960	258-1217	by synoptic hour	2c	8hrs,12mns,10yrs	22
6	1181	1-1181	OCEAN TOTAL CLOUD			
	1	1	Mean Annual	5c	1ann	22
	4	2-5	Mean Seasonal	"	4sns	22
	4	6-9	daytime	"	4sns	22
	4	10-13	Mean Seasonal	10c	4sns	22
	32	14-45	by synoptic hour	"	8hrs,4sns	22
	12	46-57	Mean Monthly	5c	12mns	22
	4	58-61	Mean Seasonal (all)	10c	4sns	22
	40	62-101	Seasonal Means(all)	"	4sns,10yrs	22
	40	102-141	Seasonal Means	5c	4sns,10yrs	22
	40	142-181	daytime	"	4sns,10yrs	22
	40	182-221	nighttime	"	4sns,10yrs	22
			Monthly means			
7	960	222-1181	by synoptic hour	5c	8hrs,12mns,10yrs	22

Table 5 continued. Data Organization

File	Number of map groups	Map group numbers	Contents (coded in group header, Table 7)	grid	groups	Data format (Table 6)
8	3247	1-3247	LAND WEATHER TYPES			
	3	1-3	Mean Annual	2c	1ann,3types	32
	12	4-15	Mean Seasonal	"	4sns,3types	32
	12	16-27	daytime	"	4sns,3types	32
	96	28-123	by synoptic hour	"	8hrs,4sns,3types	32
	36	124-159	Mean Monthly	"	12mns,3types	32
	8	160-167	Mean Seasonal (all)	5c	4sns,2types	32
	80	168-247	Seasonal Means(all)	"	4sns,10yrs,2types	32
	120	248-367	Seasonal Means	2c	4sns,10yrs,3types	32
			Monthly means			
9-11	2880	368-3247	by synoptic hour	"	8hr,12mn,10yr,3types	32
12	3215	1-3215	OCEAN WEATHER TYPES			
	3	1-3	Mean Annual	5c	1ann,3types	32
	12	4-15	Mean Seasonal	"	4sns,3types	32
	12	16-27	daytime	"	4sns,3types	32
	12	28-39	Mean Seasonal	10c	4sns,3types	32
	96	40-135	by synoptic hour	"	8hrs,4sns,3types	32
	36	136-171	Mean Monthly	5c	12mns,3types	32
	4	172-175	Mean Seasonal (all)	10c	4sns,1type	32
	40	176-215	Seasonal Means(all)	"	4sns,10yrs,1type	32
	120	216-335	Seasonal Means	"	4sns,10yrs,3types	32
			Monthly means			
13-15	2880	336-3215	by synoptic hour	5c	8hr,12mn,10yr,3types	32
16	72	1-72	HARMONICS & IAV			
	1	1	Annual TC, land	2c	1ann	40
	3	2-4	Annual WT, land	"	1ann,3types	40
	4	5-8	Diurnal TC, land	"	4sns	41
	12	9-20	Diurnal WT, land	"	4sns,3types	42
	1	21	Annual TC, ocean	5c	1ann	40
	3	22-24	Annual WT, ocean	5c	1ann,3types	40
	4	25-28	Diurnal TC, ocean	10c	4sns	41
	12	29-40	Diurnal WT, ocean	"	4sns,3types	42
	4	41-44	IAV TC, land	2c	4sns	51
	12	45-56	IAV WT, land	"	4sns,3types	52
	4	57-60	IAV TC, ocean	10c	4sns	51
	12	61-72	IAV WT, ocean	"	4sns,3types	52

\# Non-standard terms are defined in Table 8. Briefly:
TC= total cloud; WT= "weather types" (clear sky, precipitation, fog).

\## Illuminance criterion applied to total cloud and clear sky unless "all" specified. Ppt and fog always determined from all observations.

* Grid sizes are described in Table 3.
Number of boxes archived for 2c land = 2309, for 5c land = 861, for 5c ocean = 1493, for 5c land+ocean = 1820, and for 10c ocean = 230

** Months are given in the order: Dec, Jan, Feb,···Nov.
If "2types" are specified, they are clear sky and fog.
If "1type" is specified, it is clear sky.
Convention for the order of groups in a multigroup listing is:
increment left group qualifier while holding right qualifier constant.

Table 6. List of Formats for Reading Data Records*
(Total Cloud Edition)

Data class / Format number	Variables and Format
1	Lat, Lon, Land-fraction, Number of land stations
10	I4 BOX, F5.2 CLAT, F5.2 CLON, F5.4 FRL, I5 NLSTA
2	Total Cloud
22	I4 BOX, I6 NOBS, F5.2 AMT, F4.1 SD, I2 IDN, I1 LOB, I2 NSN
3	Weather Types
32	I4 BOX, I6 NOBS, F5.2 FQ, F4.1 SD, I2 IDN, I1 LOB, I2 NSN
4	Harmonic analyses
	I4 BOX, F5.2 PHASE, F5.2 AMP, F4.1 VAF, I2 NT, F4.1 AVG
40	(for annual harmonic)
41	(for diurnal AMT)
42	(for diurnal FQ)
5	Interannual variations and trends
	I4 BOX, I2 NYRS, I2 SPAN, F5.2 IAV, F6.3 TRND, F5.3 UNC
51	(for AMT)
52	(for FQ)

* Terms defined in Table 8.
Data records are 24 characters.

Table 7. Map Group Header Record Format and Codes*
(Total Cloud Edition)

Format	I4	I4	I2	I1	I1	I4	I2	I2	I2	I2
Parameter	MGRP	NBXS	SIZE	LO	IMOON	YEAR	SN	TIME	TYPE	FMT
Values	1	230	10	1=Land	0=Moon	1981	0=ann	-3night	1=TCC	10
	|	1820	5	2=Ocean	1=All	|		-2day	2=CLR	22
	3247	7290	2	3=Global		1991	1=Jan	-1daily	3=PPT	32
		861				8190	|	00GMT	11=FOG	40
		1493				8291	12=Dec	03		41
		2309						06		42
							41=DJF	09		51
							42=MAM	12		52
							43=JJA	15		
							44=SON	18		
								21		

* Terms are defined in Tables 3 & 8.

Table 8. Terms and Abbreviations Used

Term	Meaning and description
AMP	Absolute amplitude of harmonic (not normalized).
AMT	Average amount of cloud cover, given in percent.
ann	Annual.
AVG	Average AMT or FQ. In formats 40-42 it is the average of NT values.
BOX	Box number specific to grid size. See Table 3.
Cb	Cumulonimbus cloud.
CLAT	Center latitude of grid box. Values +90 to -90 for N to S.
CLON	Center longitude of grid box. Values 0 to 360 East.
day(time)	Local time 06-18.
DJF	December (of the previous year), January, February.
FMT	Data format number (see Table 6).
FQ	Frequency of occurrence; given in percent.
FRL	Fraction (0. to 1.0000) of area in grid box that is land.
GMT	Greenwich Mean Time.
IAV	Interannual variation (standard deviation of contributing year averages).
IDN	Indicates whether reports contributing to box average were from day only (=1), night only (=2), both (=3) or had less than minimum observations (=4) {see Section 2B3}.
IMOON	Indicator for application of the illuminance criterion: 0= criterion applied ("Moon"), 1= not applied ("All").
JJA	June, July, August.
hrs	Hours.
lat	Latitude.
LO	Indicator that group data are intended to be for land (=1), ocean (=2), or both (=3).
LOB	Indicator that box data were from land only (=1), ocean only (=2), both (=3), or no data (=0).
lon	Longitude.
MAM	March, April, May.
MGRP	Map group number. Increments serially through group cluster (see Tables 4 & 5).
missing value code	The integer -9. Inserted in data record where no legitimate value is reported. (In formats 51-52 use NYRS=0 for missing value code.)

Table 8 continued. Terms and Abbreviations Used

night(time)	Local time 18-06.
NLSTA	Approximate average number of land stations reporting in a 2c grid box.
NOBS	Number of observations.
Ns	Nimbostratus cloud.
NSN	Number of seasons contributing to annual average.
NT	Number of synoptic hours used (4 or 8) for diurnal harmonic analysis or number of months used (12) for annual harmonic analysis.
NYRS	Number of years contributing to trends and IAV.
mean seasonal	Long-term average; average over several years for season.
mns	Months.
PHASE	Phase of first harmonic. Diurnal: 0-24 hours mean solar time of box center (-9 if AMP=0). Annual: month (0.5 - 12.4 [1.0 = middle of January, etc.]; 0 if AMP=0).
SD	Standard deviation; in units of variable (not normalized).
seasonal mean	Average for an individual year for a particular season.
SIZE	Grid box size indicator.
SN	Season or month indicator.
sns	Seasons (DJF, MAM, JJA, SON).
SON	September, October, November.
SPAN	Span of years contributing to trend and IAV (includes first and last years contributing).
TIME	Time of day for which group data apply.
TRND	Trend. Slope of least-squares fit (change in average/yr).
TYPE	Cloud or weather type code.
UNC	Uncertainty of trend line; same units as TRND.
VAF	Percent variance accounted for by the first harmonic.
YEAR	Year or years for which group data apply. Coded as 19yr for single years where yr gives the last 2 digits of the year, and as yfyl for multi-year averages where yf=yr of the first year and yl=yr of the last year of the period of record.
yrs	Years.

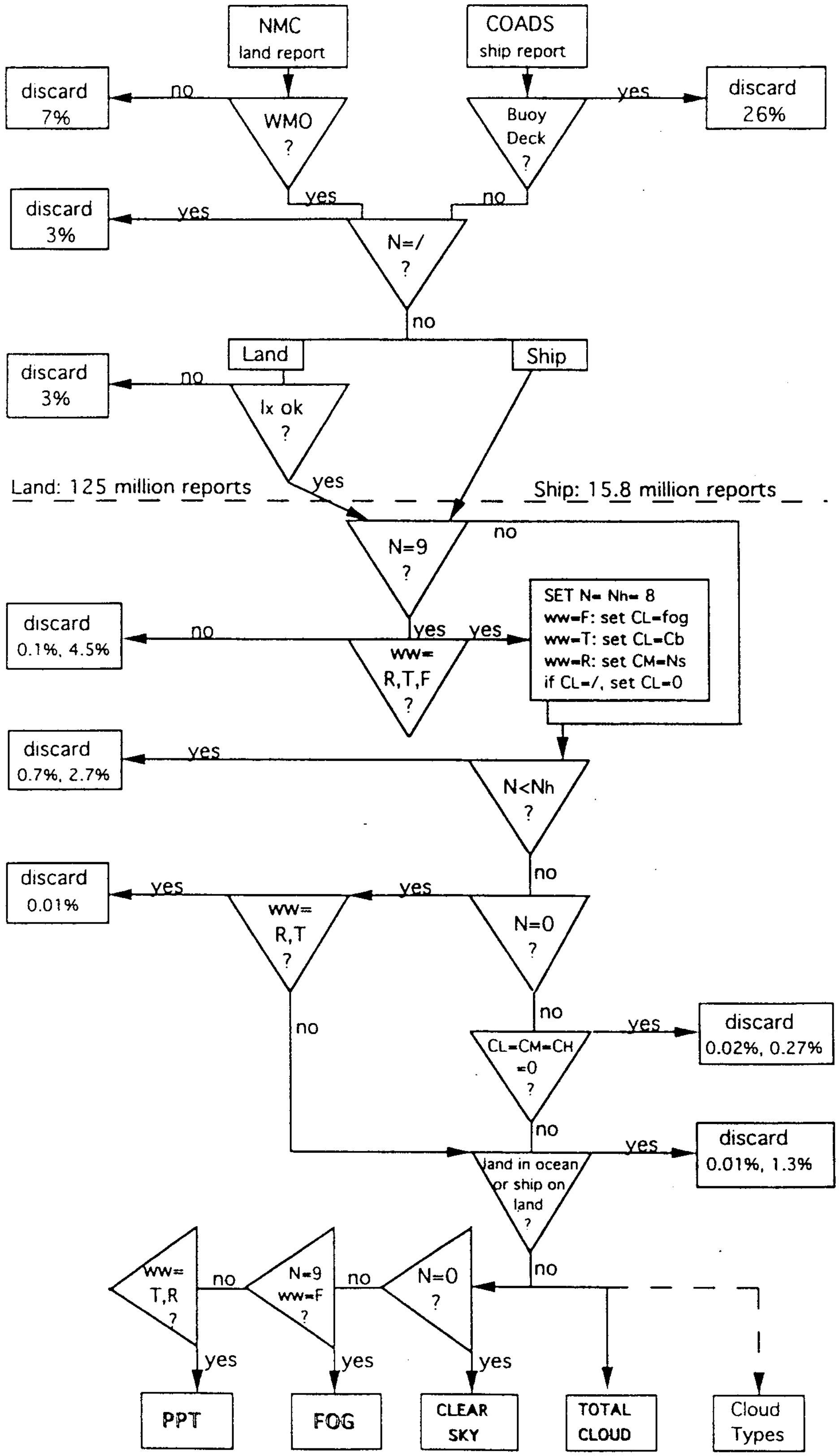

Figure 1. Flow chart of data selection and checking. Abbreviations are defined in Tables 1, 2 & 8. (Discard fractions given in order "land, ship" where needed.) See text for discussion.

Figure 2a. ANNUAL AVERAGE TOTAL CLOUD COVER (%), LAND & OCEAN, 1982-1991

from Map Group: 11820 5308291 0-1 122

LAT -90 -60 -30 0 30 60 90 LON

									79	73	70	68	71	77	77	68	65	68	71	67	32	31	25	39	46	52	64									0E
				91	88	85	87	87		72	71	67	69	74	75	68	70	75	72	70	54	29	21	28	48	48	63	68	71	76	81					
			59						78	69	63	53	57	63	61	65	76	75	66	68	41		20	35	44	48	61					83	83			
				73		92			83	63	46	32	31	35	50	68	63	63	60	53	19		24	41	42	47	61	67	65	67	73					
									80	56	43	28	33	40	50	63	70	61	59	54		11	15	38	40	54	61							79		
				81			85			63	50	35	35	40	51	54	65	74	63	67	40		13	35	34	51	61	66	69	68	69					+30E
			48						77	67	59	51	40	45	53	52	63	62	80	69	19	10	13	34	38	52	60					81	82			
				75	91		85	76		67	59	51	47	51	59	50	63	59	59	51	35	18	16	28	37	55	59	67	72	71	74					
									79	69	61	52	41	46	50	50	48	52	43	35	29	25	21	22	35	59	60									
				74	88	86	88			72	64	54	60	58	50	54	49	47	36	30	21	21	22	25	49	56	54	65	71	74	75					
			50					76	76	70	64	61	55	58	58	59	55	50	42	32	34	19	21	24	42	49	51					80	83			
				76	86					72	63	62	56	57	57	62	60	53	49	44	35	23	20	24	39	43	51	63	70	74	73					+60E
									85	71	67	62	57	58	61	62	61	56	49	47	42	34	20	22	36	37	48							81		
				69	88	92	86	83	83	73	69	64	56	59	61	64	63	59	51	48	44	34	20	27	42	43	47	59	65	69	71					
			65					77	82	73	68	62	59	62	63	67	66	60	55	53	44	33	24	34	49	49	47					69	85			
				78	93	89	85		81	77	68	62	61	60	63	68	65	62	59	54	44	38	30	32	50	53	47	59	65	71	68					
										76	68	65	60	62	69	68	69	66	61	57	52	42	38	42	48	50	51									
					92	87			82	77	68	66	64	65	67	70	70	70	68	60	56	48	44	48	51	45	54	63	68	69	70					+90E
										76	70	67	64	64	67	69	73	74	71	61	55	53	58	60	54	45	50					69	78			
				69	89	84				77	71	68	66	65	65	69	75	77	72	62	56	58	61	63	55	44	48	63	67	69	68					
									85	76	71	69	65	63	62	69	79	80	68	64	55	63	64	69	55	41	46							70		
				72	88	83	81		82	74	69	65	62	56	59	67	73	69	67	64	66	72	79	72	49	36	46	63	72	69	62					
		45							76	73	57	45	36	45	51	61	75	78	68	62	61	69	73	64	50	40	46					66	70			
				73	88	87	83		82	69	53	32	33	33	49	56	71	71	69	59	58	69	71	62	48	41	45	54	69	66	71					+120E
									82	67	47	33		37	44	52	66	62	67	66	61	69	73	63	52	45	46									
				85	86	87	82		80	71	52	31		39	43	58	67	65	67	64	61	66	72	67	56	54	48	53	68	66	61					
									79	72	51	31	32	34	49	60	73	69	68	64	59	60	68	66	64	54	54					67	76			
				80	85	88	84	78	76	67	43	28	31	35	57	62	72	69	68	63	59	59	65	67	69	61	59	61	63	64	61					
								77	73	65	40	29	33	40	60	69	72	68	66	60	57	57	64	73	68	68	67							68		
				72	94	87	86	78	61	59	38	34	43	53	63	76	69	66	64	59	56	57	63	75	76	75	76	73	74	61	62					+150E
								79	70	61	52	49	50	58	64	68	68	65	67	59	54	57	63	75	80	82	83					70	82			
				83	96	89	84		73	68	62	56	55	59	67	69	65	69	68	60	54	55	63	74	82	85	85	76	75	65	65					
								78	77	70	64	58	56	61	68	70	67	66	67	60	53	55	61	73	83	86	86									
				88	90	85	85	79	72	70	65	62	61	63	67	70	65	63	69	61	53	56	61	72	83	86	86	80	76	70	63					
		65	84					76	61	62	63	64	64	67	67	68	61	65	68	62	53	57	59	72	82	86	87					78	70			
51				92	89	87	85	79	63	59	65	66	66	65	68	65	62	67	69	61	57	56	61	71	82	87	87	88	83	71	63				72	+180E
								79	74	67	65	66	65	67	68	68	58	63	69	62	58	55	62	70	81	86	87							75		
								84	76	70	68	67	67	65	66	65	55	60	70	64	58	55	62	71	80	85	86	88	89	86	73					
		86	87					79	77	74	67	67	65	64	66	61	53	58	70	61	57	56	61	70	80	85	86					74	82			
				88				82	78	73	69	68	66	63	62	56	52	59	73	62	56	56	62	71	80	85	86	86	86	73	73					
								83	74	72	71	68	68	63	60	52	49	55	72	62	55	55	62	72	79	85	87									
								83	74	78	72	73	69	60			49	56	72	63	59	59	62	72	80	85	86	86	75	72	53					+210E
										77	74	72	67	62	55	49		52	73	65	61	62	66	72	79	85	87					69	78			
				91			90			78	75	74	65	61	54	47	45	53	74	68	67	67	70	72	79	85	86	87	82	71	67					
									85	86	73	71	64	56	54	56	48	56	74	72	70	72	73	75	80	84	84							68		
				93			88	82		78		70	63	52	49	59		53	71	71	73	77	75	76	78	81	82	82	80	67	63					
			86					80				67	61	54	48	45		53	70	69	74	78	76	74	72	73	74					50	77			
									86			66	57	52	48	46	48	56	73	68	73	75	73	64	55	63	69	71	68	67	64					+240E
									82			61	57	53	52	47	53	56	72	65	67	65	61	54	41	54	62									
							85		85				59	57	51	51	51	61	71	62	59	45	35	27	49	57	63	64	64	62	65					
									79			62		55	54	54	57	64	69	58	51	43	38	35	49	54	61					69	73			
							83		81	76				59	62	61	55	64	67	54	48	44	47	47	50	55	59	61	65	63	64					
	66								78	78				64	69	66	56	70	66	50	49	56	57	51	52	55	60							56		
							81		79	75						72	67	76	62	52	55	52	58	56	56	56	63	64	66	63	64					+270E
		69							77	76	73	71	71	73	75	73	69	77	60	57	61	53	57	57	58	63	65					66	77			
							83	83	79	75	71	70	76	79	76	67	70	78	68	67	56	53	54	57	63	66	67	68	71	72	67					
								84	77	74	69	72	80	78	68	65	75	75	70	62	52	52	57	61	59	66	66									
				87		86	78	61	58	56	56	70	74	63	50	62	68	73	76	53	51	53	57	65	64	64	68	69	72	69	69					
			73					58	54	46	43	47	56	54	66	69	77	81	71	55	52	54	58	64	70	67	66					71	61			
				81	85	82	68	61	56	48	48	48	56	63	61	65	67	65	74	55	53	54	56	63	73	71	68	70	70	77	72					+300E
								63	56	56	51	47	52	56	60	65	58	62	57	57	53	52	56	62	72	78	73							61		
					87	85	75	73	66	61	57	53	50	56	52	63	66	64	62	60	53	52	55	61	72	78	77	75	81	77	71					
		69						77	71	66	63	66	61	54	49	56	64	62	66	61	55	52	55	60	69	77	83					63				
					94	92	88	81	71	69	65	63	58	51	51	51	55	63	69	61	56	54	54	59	68	78	85	87	84	69	50					
								81	71	70	69	63	60	56	53	56	54	63	69	64	60	53	55	60	67	76	83									
				94	96	92	80	86	77	70	67	65	57	55	51	53	54	63	68	68	63	56	57	61	67	75	82	86	87	84	73					+330E
		68	80					86	76	75	70	62	59	54	51	50	55	66	70	63	59	54	57	62	68	76	82					63				
				92	95	92	86			72	71	62	55	53	53	51	54	64	64	59	57	56	57	64	70	77	82	84	83	83	83					
									77	73	69	62	55	58	57	55	52	65	59	49	41	35	49	62	70	76	79							70		
				90	95	91			81	73	71	63	58	62	66	60	54	67	62	51	43	30	49	60	65	68	78	80	81	81	82					
			66						80	74	70	63	65	67	70	62	57	68	60	49	36		23	45	45	59	72					81	77			
				82	87	85				74	71	67	70	75	77	68	61	68	63	67	35		23	38	45	57	66	71	77	82	85					360E

-90 -60 -30 0 30 60 90N

Figure 2b. ANNUAL PRECIPITATION FREQUENCY (%), LAND & OCEAN, 1982-1991

from Map Group: 31820 5318291 0-1 332

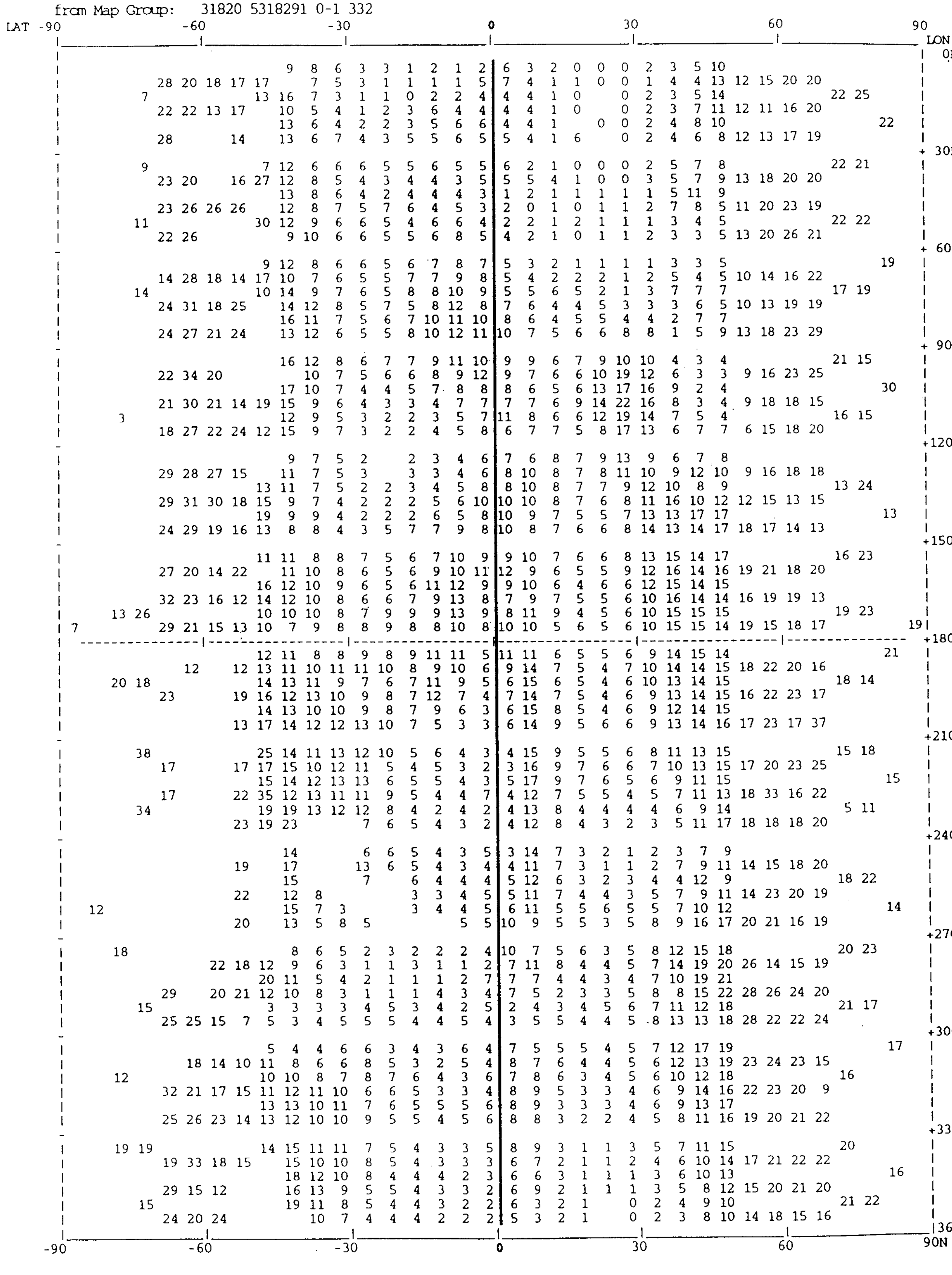

Figure 3a. ANNUAL CYCLE in Total Cloud Cover for (1982-1991) Ocean

PHASE (Month of Maximum) from Map Group: 211493 5208291 0-1`140

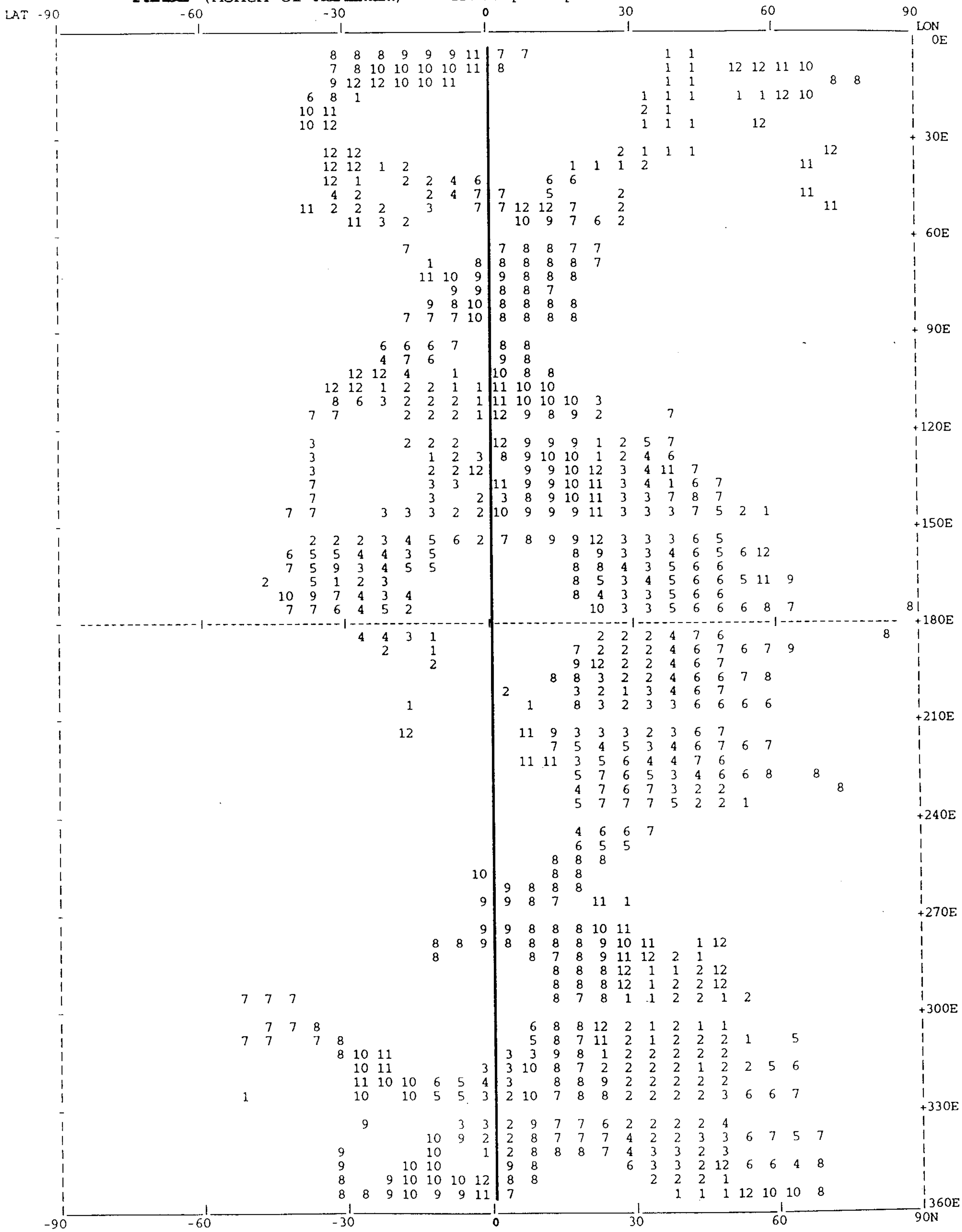

Figure 3b. ANNUAL CYCLE in Precipitation Frequency for (1982-1991) Ocean

PHASE (Month of Maximum) from Map Group: 231493 5218291 0-1 340

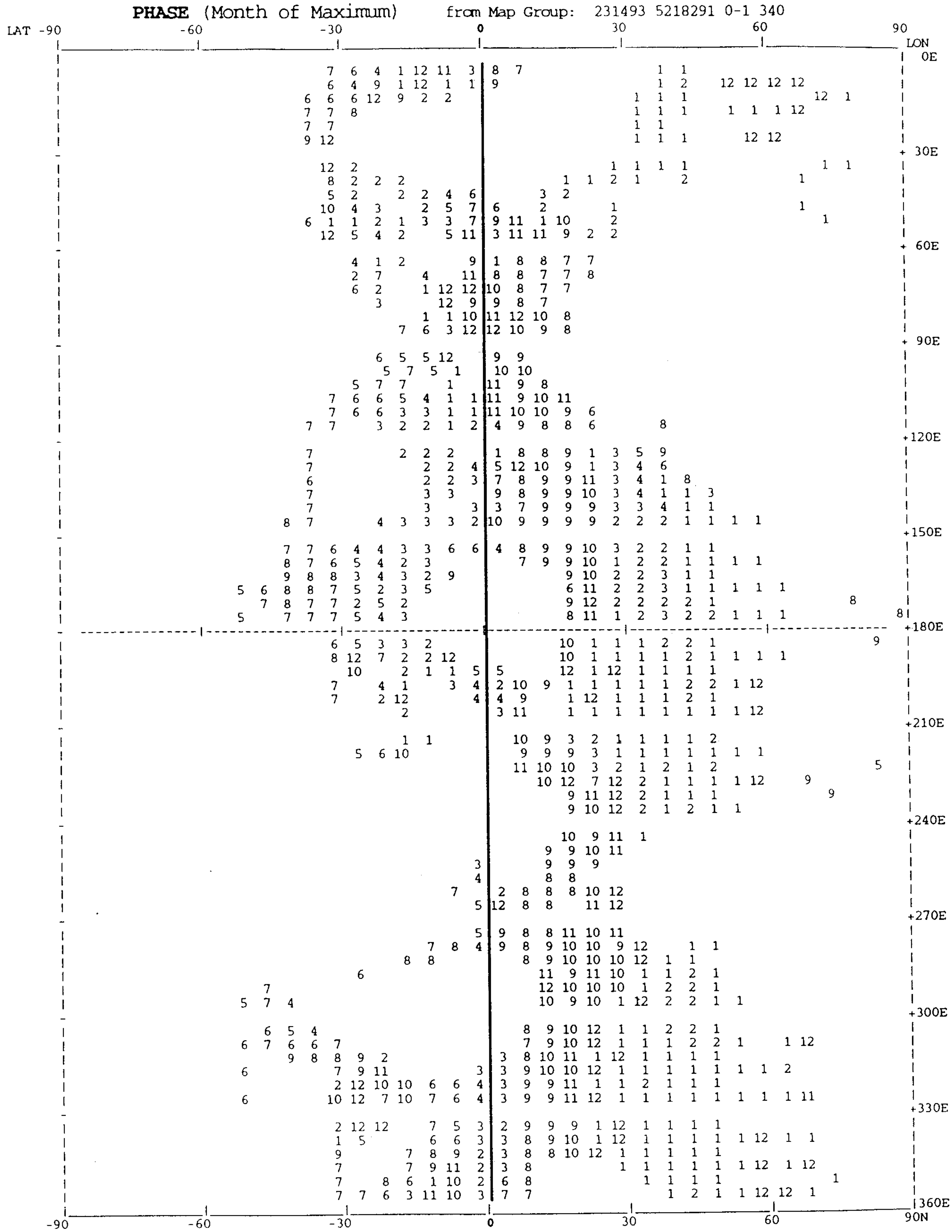

Figure 3c. ANNUAL CYCLE in Fog (sky obscured) Frequency for (1982-1991) Ocean

PHASE (Month of Maximum) from Map Group: 241493 5218291 0-11140

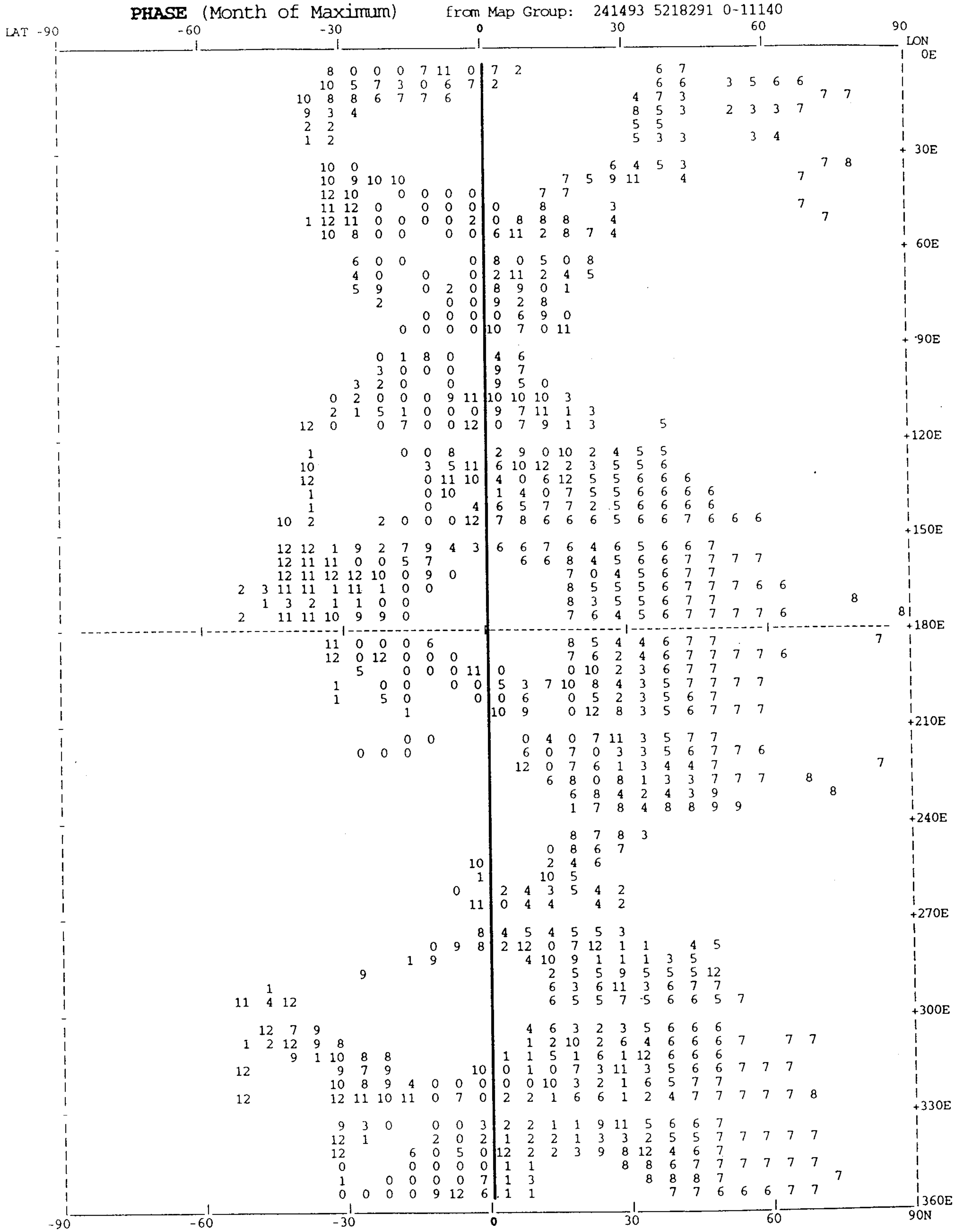

Figure 4a. DIURNAL CYCLE in Total Cloud Cover for DJF (1982-1991) Ocean

AMPLITUDE (% Cloud Cover) from Map Group: 25 2301020829141-1 141

Lat N60 — 90 — 180 — 270 — 360E

3 1 0 2 2 2

3	4					7	1	1	0	1	1		1	0	1	0	1
6	5					3	2	1	1	1	1	2	1	3	2	1	3
	5	5	6		7	1	1	1	2	2	2	3	4	0	1	1	4
	7	9	2	2	4	0	1	1	1	2	3	3	5	1	1	2	1
7		2	3	2	3	2	3	3	2	3	4	2	2	6	1	2	8
5		3	3	1	2	2	2		2	3		6	10			2	6
7		4	2	3	2	3	3	2	2	2		9		7		4	10
10	1	2	4	6	4		1	0	1	0	1				2	5	6
5	3	3	5		5	4	4	3	2				3	3	1	2	3
								2						2	2		

2 2 2 3 2

Lat: 50, 40, 30, 20, 10, 0, -10, -20, -30, -40, -50, -60

Lon 0 — 90 — 180 — 270 — 360E

PHASE (Local Time of Maximum)

Lat N60 — 90 — 180 — 270 — 360E

14 18 15 9 13

12	9					11	4	7		6	12		8		5		12
11	12					9	12	17	3	8	21	11	4	11	7	9	11
	10	10	13		7	19	1	23	3	5	3	12	10		8	7	8
	10	9	9	13	9		21	4	4	6	2	14	7	10	6	6	11
13		6	12	11	11	11	17	24	2	5	24	24	7	11	5	8	10
7		13	18	17	6	7	14		18	8		4	4			10	6
5		12	20	1	23	10	14	21	18	14		4		4		12	5
6	6	21	1	3	24		5		21		15				10	12	5
5	4	9	2		5	5	6	7	5				7	11	8	4	5
								6						2	12		

2 24 6 4 4

Lat: 50, 40, 30, 20, 10, 0, -10, -20, -30, -40, -50, -60

Lon 0 — 90 — 180 — 270 — 360E

Figure 4b. DIURNAL CYCLE in Total Cloud Cover for MAM (1982-1991) Ocean

AMPLITUDE (% Cloud Cover) from Map Group: 26 2301020829142-1 141

Lat N60	2						1			2	1				3		0	
50	3	5					3	2	2	2	2	2		4	2	1	2	2
40	4	5					2	1	1	2	2	2	4	5	4	1	3	3
30		4	4	1		1	1	1	2	2	1	4	5	3	3	1	3	7
20		5	4	2	5	4	2	1	2	1	2	4	4	5	3	3	4	3
10	4		3	3	3	3	2	2	1	2	3	2	1	3	2	2	2	5
0	4		3	1	2	2	2	1	2	2	0		1	6			1	2
-10	4		3	1	1	1	3	1	1	3	2	3	3	5	5		1	7
-20	4	3	0	4	2	1		3	0	1	3	2			3	1	1	4
-30	2	3	2	2	3	4	3	2	2	2	2			6		2	3	2
-40								6	4					1	4	1		
-50										1						1		1
-60 Lon 0					90					180				270				360E

PHASE (Local Time of Maximum)

Lat N60	11							9		3		2				5		
50	11	10					11	6	3	3	24	8		12	10	6	4	9
40	10	12					6	3	3	3	2	5	6	12	12	13	4	7
30		11	11	9		4	6	5	2	1	3	2	8	12	12	9	5	6
20		9	8	9	10	11	11	17	7	12	2	4	6	9	9	9	7	10
10	12		12	10	12	12	17	23	2	1	1	21	10	9	11	7	8	9
0	7		14	14	17	8	16	22	16	0			22	4			13	8
-10	5		12	4	21	8	11	12	16	17	11	16	5	3	6		12	5
-20	3	7		1	2	9		13		1	8	20			4	9	10	4
-30	3	8	3	8	4	9	6	10	9	7	5			11		12	9	6
-40								9	10					10	18	1		
-50										17						11		8
-60 Lon 0					90					180				270				360E

Figure 4c. DIURNAL CYCLE in Total Cloud Cover for JJA (1982-1991) Ocean

AMPLITUDE (% Cloud Cover)   from Map Group: 27 2301020829143-1 141

```
Lat
N60+----------------------------+---------------------------+-------------------------+-------------------------+
            2                                  4            1          2                       2           2
 50
        2     4                             5     2     1     2     2     2           4     2     2     4     2
 40
        4     4                             2     2     0     1     3     5    11     5     4     1     4     5
 30
              1     4     5           4     1     3     1     1     3     5     6     6     3     2     3     8
 20
              3     5     1     1     2     2     3     1     1     3     3     3     3     3     3     5     7
 10
        4           6     1     1     2     0     0           2     1     3     2     1     3     2     1     2
  0+----------------------------+---------------------------+-------------------------+-------------------------+
        7           1     1     2     5     4     1           1     3           2     4                 2     7
-10
        3           3     3     2     2     4     2     3     3     1     2     4           5           1     6
-20
        3     4     1     4     3     2           1     1     2     3     1                       6     1     4
-30
        3     5     1                 2     1     2     3     1     1                 3           5     3     1
-40
                                                  3     4                       1     4     1     3
-50
                                                                                               3            5
-60+----------------------------+---------------------------+-------------------------+-------------------------+
Lon 0                           90                         180                       270                      360E
```

PHASE (Local Time of Maximum)

```
Lat
N60+----------------------------+---------------------------+-------------------------+-------------------------+
           8                                   6             6         5                       4           2
 50
        10    14                            9     7     3     4     2     4           11    12    8     5     8
 40
        10    9                             9     5           4     3     7     7     14    13    20    4     6
 30
              12    9     8           12    11    15    19    18    3     4     8     13    14    14    5     9
 20
              8     9     12    11    14    18    14    15    22    1     2     3     9     14    12    10    14
 10
        10          12    15    3     10                      16    12    5     1     0     12    12    21    8
  0+----------------------------+---------------------------+-------------------------+-------------------------+
        8           21    19    15    8     8     9           21    7           3     6                 6     6
-10
        9           11    5     23    7     9     22    1     24    8     5     3           6           9     5
-20
        6     9     4     3     3     5           6     24    1     2     0                       11    8     3
-30
        9     9     22                10    11    10    13    7     1                 17          11    10    1
-40
                                                  11    13                      15    20    12    11
-50
                                                                                               12           11
-60+----------------------------+---------------------------+-------------------------+-------------------------+
Lon 0                           90                         180                       270                      360E
```

Figure 4d. DIURNAL CYCLE in Total Cloud Cover for SON (1982-1991) Ocean

AMPLITUDE (% Cloud Cover)   from Map Group: 28 2301020829144-1 141

```
Lat
N60+-------------------+------------------+----------------+----------------+
          2                       2       1       2               2       1
 50
        3   5                   3   2   2   1   1   2       3   2   1   1   3
 40
        5   3                   1   1   1   1   2   3   4   4   3   2   1   3
 30
            4   2   1       4   2   1   1   1   1   2   3   4   3   2   2   4
 20
            8   4   1   3   1   1   1   2   2   1   3   1   2   2   2   4   6
 10
        3       3   2   1   1   1   2   2   5   1   2   5   1   3   3   1   4
  0+-------------------+------------------+----------------+----------------+
        7       2   1   1   3   3   2       0   1       9   8           2   9
-10
        3       6   2   1   3   6   1   1   2   0               7       3   8
-20
        5   6   1   4   7   2       3   3   1   2   2           3   2   2   5
-30
        2   4   5           1   4   4   3   4   2           2   1   2   1   3
-40
                                2   3                           1   2
-50
                                      1                       3       1
-60+-------------------+------------------+----------------+----------------+
Lon 0                 90                180              270          360E
```

PHASE (Local Time of Maximum)

```
Lat
N60+-------------------+------------------+----------------+----------------+
         13                      12       8       9              11      11
 50
       11  12                  11   9   8   1   5   9      11  11   7   3  11
 40
       11  12                   1   8   4   4   4   8   7  14  13  13  17  11
 30
            8  10   4       7  21  11  21  23   4   3   9  13  17  14  10  12
 20
            8   7  12  13   9  14  21  21   4   9   1  15   9  14  13  12  13
 10
        8       8  13   2  13   0  17  17   2   8   4   4   6   8  14   4   8
  0+-------------------+------------------+----------------+----------------+
        7      18  19  16   8  11  11           1       6   6           6   6
-10
        6      10   0  23   5  10   5  18  20                   7       7   5
-20
        5   6   2   3   3   4       6   2  18   2   0           3   3   3   3
-30
        4   5   4           4   7   8   6   1   7           5   3  12   1   2
-40
                               10  11                          15  13
-50
                                      4                       4       9
-60+-------------------+------------------+----------------+----------------+
Lon 0                 90                180              270          360E
```

Figure 5a. DIURNAL CYCLE in Total Cloud Cover for DJF (1982-1991) Land over Asia

AMPLITUDE (% Cloud Cover) from Map Group: 52309 210829141-1 141

```
   Lat
   N50+------+-----------+-----------+-----------|-----------+-----------+-----------+-----+
         2  4  4  3  1  2  1  3  1  3  3  4  2  4  4  4  3  3  4  6  5  7  5  6  4  4  3  3

         1  6  2  2  4  3  2  3  3  2  2  2  1  3  5  4  3     4  3  4  2  3  5  5  2  4  3
    45+
         2  4  3  4  3  4  3  1  4  7  1  2  1  4  5  5           2  2     5  5  6  6  5  3

         5  5  8  6  5  4  4  3  4  4  6  5  3  5     6  4  4  4  2  3  3  5  5  4  4  4  3
    40+------+-----------+-----------+-----------+-----------+-----------+-----------+-----+
         5  4  6  7  6  4  3  2  2  4     0  4  2  8  3  3  8  7  5  1  3  2  1  2  2  5  1

            5  3  7  4  4  6        4  4  6          10  5  5  5  2  3  1  1  1  1  2  1  3
    35+
                           7  5        7             14 10  9  9  8  5  4  2  1  3  2  2

                     8 10  4  5  3     5 14    13 14 11 10 11 11  5  8  6  2  1  3  3  2  2
    30+------+-----------+-----------+-----------+-----------+-----------+-----------+-----+
                  5  6  3     2  2           5 11 14  9     4  4  8  6  7  6  5  4  6  3

         6     5        3  3  3  4  5  3     4  4  6     3  6  5 12 10  9  6  6  9  8  3
    25+
         6  6        5  2     4  5  5  7     2  5  6       22 12 11 10  8  7  7  8  5  3  1

            9              3  3  5  4  4  3  7     4          31     9 10  6  7  3     2
    20+------+-----------+-----------+-----------|-----------+-----------+-----------+-----+
   Lon      60          70          80          90         100         110         120  E
```

PHASE (Local Time of Maximum)

```
   Lat
   N50+------+-----------+-----------+-----------|-----------+-----------+-----------+-----+
         8  7  8  9  4  6  8  9  7  7  7  5  9 12 11 11 12 10 13 12 12 13 12 12 12 10 12  8

         7  4  9  8 12  4 10  8 11 14 11  8  8 12 14 14 14    14 14 12 13 10 11 13 12 10 14
    45+
         6 12 10 11 12 12 12 11 12 16 13  8 11 10 14 13          14 11    13 11 12 13 13 13

        12 12 11 11 12 12 13 12 13 14 14 14 11 14    12 12 17 16 15 12 12 13 13 12 12 12 13
    40+------+-----------+-----------+-----------+-----------+-----------+-----------+-----+
        13 13 12 13 14 13 12 15 15 13    14 18 14 16 17 16 16 18 17 17 14 15 20  7 12 12 15

           15 13 14 15 15 16       20 19 20          17 18 19 18 22  0  8  1  1 22 20 12 12
    35+
                          16 15       18             17 18 18 18 22  2  4  4  3 23  0 23

                    16 16 16 15 16    17 17    17 19 19 17 16 18 22  7  7  5  4  2  1  3  6
    30+------+-----------+-----------+-----------+-----------+-----------+-----------+-----+
                 15 16 16    15 12          16 17 18 23     8 15  2  6  5  7  5  5  6  4

        12    12       15 15 13 14 13 12    12 15 21     7 12 12  7  6  5  5  6  6  5  5
    25+
        12 14       13 11    13 14 13 14    15 13 13        7  9  8  7  6  6  6  6  5  2 11

           11             12 11 14 14 14 17 13    13           6     7  7  7  6 13    20
    20+------+-----------+-----------+-----------|-----------+-----------+-----------+-----+
   Lon      60          70          80          90         100         110         120  E
```

Figure 5b. DIURNAL CYCLE in Total Cloud Cover for JJA (1982-1991) Land over North America

```
          AMPLITUDE (% Cloud Cover)          from Map Group:   72309 210829143-1 141
 Lat
 N50+------+-----------+-----------+-----------|-----------+-----------+-----------+------+
       4  5  3  9  5        2  4     7  5 10 10  8  9  4  9  7     7  9  6  6  6     2  6

       7  1  4     6  7  9        2     4     8  9  7  7 11  9 10  7  8  7  8  6  5     3
  45+
       3        3  5     7 10  6     3  3  7     9 12 10  8  9  4  5  4     1  2  2

       4     8        4        10  5  6  5  6 14  8 12  9 12    12  7  6  1
  40+------+-----------+-----------+-----------+-----------+-----------+-----------+------+
         14  9     13     7     12 10  5  5  6  9 10 10  9  8     5 12

             5  5           14     1  6  6 11 10  7  7  3  2  3  4
  35+
            18 24     5            2  4  6     11    12  4  4

                   2  9 13 10      2  6  7 10  9 12  9 11 10                      3
  30+------+-----------+-----------+-----------|-----------+-----------+-----------+------+
 Lon      120         110         100          90          80          70          60  W


          PHASE (Local Time of Maximum)
 Lat
 N50+------+-----------+-----------+-----------+-----------+-----------+-----------+------+
       7  5 17 15 15       17 11     11 12 12 12 13 13 11 13 12    13 14 14 13 14    10 12

       6 10 17    17 18 20        10     10    12 12 13 12 13 12 13 13 13 14 14 14 11     4
  45+
       7        16 16    18 17 21     5 10 11     12 12 13 12 13 14 13 14     3 13 12

       5     18       19       18  2  4  7 10 11 12 12 13 13    13 14 14 14
  40+------+-----------+-----------+-----------+-----------+-----------+-----------+------+
          3 17    16     18     19  0  5  8  9 12 11 12 12 11    15 13

            13 15          20     23  8  9 11 13 12 13 11 18 14 14
  35+
             5  4     24           5  8 11     12    13 14 16

                  13 20 20 22     12  9 11 13 13 14 13 15 15                      15
  30+------+-----------+-----------+-----------+-----------+-----------+-----------+------+
 Lon      120         110         100          90          80          70          60  W
```

APPENDIX D

EDITED SYNOPTIC CLOUD REPORTS FROM SHIPS AND LAND STATIONS OVER THE GLOBE, 1982-1991

(Documentation)

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Abstract

Surface synoptic weather reports for the entire globe for the 10-year period from December 1981 through November 1991 have been processed, edited, and rewritten to provide a data set designed for use in cloud analyses. The information in these reports relating to clouds, including the present weather information, was extracted and put through a series of quality control checks. Reports not meeting certain quality control standards were rejected, as were reports from buoys and automatic weather stations. Correctable inconsistencies within reports were edited for consistency, so that the "edited cloud report" can be used for cloud analysis without further quality checking. Cases of "sky obscured" were interpreted by reference to the present weather code as to whether they indicated fog, rain or snow and were given appropriate cloud type designations. Nimbostratus clouds, which are not specifically coded for in the standard synoptic code, were also given a special designation. Changes made to an original report are indicated in the edited report so that the original report can be reconstructed if desired. While low cloud amount is normally given directly in the synoptic report, the edited cloud report also includes the amounts, either directly reported or inferred, of middle and high clouds, both the non-overlapped amounts and the "actual" amounts (which may be overlapped). Since illumination from the moon is important for the adequate detection of clouds at night, both the relative lunar illuminance and the solar altitude are given, as well as a parameter that indicates whether our recommended illuminance criterion was satisfied.

This data set contains 124 million reports from land stations and 15 million reports from ships. Each report is 56 characters in length. The archive consists of 240 files, one file for each month of data for land and ocean separately. With this data set a user can develop a climatology for any particular cloud type or group of types, for any geographical region and any spatial and temporal resolution desired.

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1. INTRODUCTION

Surface synoptic weather reports are readily available in data sets such as those prepared by the National Meteorological Center (NMC) and the U. S. Navy Fleet Numerical Oceanography Center (FNOC). For marine reports there is also the Comprehensive Ocean-Atmosphere Data Set (COADS). Those data sets are archived at the National Climatic Data Center (NCDC) in Asheville, North Carolina, and at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. The data set described here includes only the information from the synoptic weather report that directly relates to clouds, as well as some derived quantities that aid in cloud analysis. It was developed as an intermediate stage in our own global analysis of total cloud cover (Hahn et al., 1994a) and cloud types, but should be useful to other researchers who wish to compare individual surface cloud reports to concurrent satellite-derived cloud data for example, or who wish to obtain averages over time or space scales not already provided in existing archives.

The cloud report provided in this data set, referred to as the "edited cloud report" (ECR, or ECRA when referring to the archive of all reports), has several features that make it desirable and easy to use in cloud analyses:

1) Synoptic weather reports contain information in addition to clouds, such as air temperature, pressure, winds, humidity, visibility, past weather and, for ships, sea surface temperature and ocean wave parameters. The ECR excludes these data, thus reducing the data volume.

2) Data sets of synoptic weather reports include reports that do not contain cloud information, such as those from automated weather stations on land and buoys in the oceans. These are not included in the ECRA.

3) The cloud portion of the synoptic report occasionally contains obvious errors or inconsistencies which must be checked for to avoid inclusion of detectably erroneous data in an analysis. Quality control procedures developed over years of analyzing surface cloud reports have been applied so that erroneous or inconsistent reports have either been excluded or, if possible, corrected before inclusion in the archive.

4) While the amount of low cloud is directly coded in the synoptic report, the amounts of middle and high clouds are not, but may often be inferred. Where possible for upper level clouds, the ECR includes both the "actual" cloud amount (sometimes requiring use of the random-overlap assumption) and the non-overlapped amount, which is simply that portion of the cloud that is visible from below and requires no assumptions.

5) Although all reports that meet the above criteria are included in the ECRA, it has been shown that many of the nighttime reports are made under conditions of insufficient (moon)

light for adequate detection of clouds. Use of such reports results in an underestimate of nighttime cloudiness by about 4% globally and has a profound influence on computed diurnal cycles in cloudiness (Hahn et al., 1994b). Reports made under conditions that satisfy the criterion for adequate illumination specified by Hahn et al. (1994b) are flagged in the ECR, and both the relative lunar illuminance and the solar altitude are given as well.

The edited cloud report archive described here covers the ten-year period December 1981 to November 1991. These beginning and ending months were chosen to coincide with the boundaries of the traditionally-defined seasons December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON). Since December 1981 is considered to be part of DJF 1982, the 10-year period is referred to as 1982-1991. This particular 10-year period was selected to coincide with the International Satellite Cloud Climatology Project (ISCCP; Rossow and Schiffer, 1991) and to extend our previous climatologies (Hahn et al., 1988; Warren et al., 1986 {hereafter referred to as W86}; Warren et al., 1988 {hereafter referred to as W88}), which terminated in (November) 1981.

Non-standard terms used in the following discussions are defined in the glossary of terms and abbreviations in Appendix B.

2. DATA SOURCES

The NMC data set (obtained from NCAR) was the source of the synoptic weather reports used for land stations. About 144 million reports (22 gigabytes of data) were processed. Only those stations assigned official station numbers by the World Meteorological Organization (WMO) were used. Synoptic reporting hours are 00, 03, 06, 09, 12, 15, 18, 21 Greenwich Mean Time (GMT). In the NCAR archive the 6-hourly reports (00,06,12,18 GMT) are stored in separate files from the intermediate 3-hourly reports (03,09,15,21 GMT) and we processed them in tandem for each month. Within each of these two groups the reports are sorted by time.

The COADS Interim Product CMR5 Reports (Woodruff et al., 1987) were the source of the ship data used (also obtained from NCAR). About 22 million reports (540 megabytes of data in packed binary format) were processed. Many of these reports are from buoys, however, and do not contain cloud information. For an individual month these data are sorted first by 2-degree latitude x longitude boxes and then by day and hour. COADS merges a dozen or so subsets of ship data and, as such, is the most extensive record of climatic data for the sea surface. However, the Interim Products available at the time of our analysis lack much of the digitized ship logbook data from foreign countries which may be delayed 2 - 5 years (Woodruff et al., 1992). Thus future releases of COADS will contain more data than were utilized here.

3. PROCESSING OF WEATHER REPORTS

A. Cloud Information in Synoptic Reports and the "Extended" Cloud Code

Synoptic weather reports are coded according to the system given by the World Meteorological Organization (WMO, 1988). The information in these reports that relates to cloud analysis is summarized in Table 1. All other parameters were ignored in our processing. A more detailed breakdown of the definitions of the cloud and weather types, as used here, is given in Table 2. The table shows the synoptic codes that correspond to various precipitation types (ww codes) as well as the codes that correspond to the various cloud types defined within each of the three reporting levels: low, middle and high (C_L, C_M, C_H).

We give special consideration to the cloud type nimbostratus (Ns), which is not specifically defined in the synoptic code. Codes C_M= 2 or 7 may signify Ns but may also signify As or Ac, respectively. We consider these codes to signify Ns when there is concurrent precipitation in the form of drizzle, rain, or snow as indicated in the present weather code ww (symbolized as D, R and S, respectively). To distinguish Ns from As/Ac we "extend" the synoptic code for C_M to include the values 12 and 11 to represent these cases of C_M= 2 and 7, respectively. The extended code values are entered in the edited cloud report (Section 4) without loss of the information content in the original report.

Nimbostratus is also considered to be present when C_M= / and specified combinations of precipitation and low cloud types are present (Table 2). These cases are given the extended code C_M= 10. This definition for nimbostratus has been simplified from that used in our previous work (W86, W88). Cases of C_M=/ with low stratus and drizzle are no longer defined to be Ns. This will cause a slight reduction in computed Ns amounts (Section 5C).

Special consideration is also given to the case of N=9 (sky obscured). If ww indicates that the sky was obscured due to F, Ts, or DRS (Table 2), the cloud type is considered to be fog, Cb, or Ns, respectively, and is given the extended code C_L=11, C_L=10, or C_M=10, respectively, and the value of N is set to 8 oktas.

All the changes described here are coded in a parameter called "the change code" (Section 3C below) which is also included in the edited cloud report (Section 4), so that unchanged reports could be reconstructed if desired.

B. Processing Through the Total Cloud Stage

A cloud report may be suitable for total cloud analysis even if cloud type information is incomplete. Certain inconsistencies within the cloud type portion of the report may, however, make the whole report suspect and cause it to be rejected even for total cloud analysis. The processing and quality control checks performed on each weather report read from the original archives (NMC or COADS) and designed to ensure suitability for total cloud analysis are shown in the flow chart in Figure 1. The percentage of reports discarded at each stage of the processing, which is discussed in the following paragraphs, is indicated.

In the early stages of processing, land and ship reports required slightly different checks (upper portion of Figure 1). A land station that did not have a WMO station number was discarded (most of these were from the United States), thus ensuring more uniformity in reporting procedures. A ship report known to be from a buoy (by the "deck" number in the COADS data) was discarded. Any report that had no cloud information (N=/) was discarded.

In 1982 WMO introduced several changes in the coding procedure (WMO, 1988). One of these changes now instructs observers to set ww=/ if present weather was either "not available" or "observed phenomena were not of significance" (ww codes 00-03 are considered to represent phenomena without significance). The present weather indicator, I_X, is used to distinguish these cases. Land station reports with I_X values of 4, 5 or 6 signify automatic weather stations and were discarded. Reports with I_X=3 (data not available) were also discarded because without ww it is not possible to interpret cases of N=9 (see W86) or to evaluate the occurrence of precipitation. I_X=2 indicates that observed phenomena were not of significance, while I_X is coded as "1" when ww is given. Occasionally I_X=1 when ww=/; these inconsistent reports were also discarded.

Examination of the NMC data set showed that while land stations adopted this new coding procedure almost immediately, I_X was not consistently coded in ship reports until 1985, as ship observers tended to continue reporting ww in accordance with the old rules. The COADS data set does not even contain I_X. Thus ship reports could not be screened on the basis of I_X.

At the upper horizontal dashed line in Figure 1, 125 million land reports and 15.8 million ship reports remained. The discard fractions below the line are fractions of these numbers. If the reported latitude and longitude of a land station put the station on water (rare) or if reported latitude and longitude of a ship put the ship on land (0.3%), the report was discarded. A land station was considered to be on water (or a ship on land) if the 5x5 degree latitude x longitude box in which it was reported to reside was 100% ocean (or land) as defined in W86. Exceptions to this are that a number of boxes with small islands were allowed to contribute to the land data and reports from the Great Lakes and the Caspian Sea were allowed to contribute to the ship data.

If the sky was obscured (N=9) by fog (ww=F; 1.1% land, 2.7% ship), thunderstorms-showers (ww=Ts, abbreviated as T in the figure; 0.05% land, 0.1% ship), or drizzle-rain-snow (ww=DRS, abbreviated here as R; 0.4% land, 0.9% ship), the sky was considered to be overcast (N=8). This source of "cloudiness" contributed about 1% to the total cloud cover globally, and much more in some locations and seasons (Hahn et al., 1992). Clouds could not be inferred if the sky was obscured for other reasons, such as blowing dust or snow, and such reports were discarded. The change code, IC=1 (discussed in Section 3C below), signifies that a report came through the N=9 branch of the processing. Thus 1.5% of the land reports and 3.7% of the ship reports had N=9 with the ww codes D, R, S, F or Ts.

Other data consistency checks indicated in Figure 1 ensure that the low cloud amount is not greater than the total cloud cover, that precipitation (as defined in Table 2) is not reported with a clear sky, and that if cloud is present (and types are reported), some cloud type must be indicated in at least one of the three possible levels (this test actually discards a report if N>0 and C_L=0 and $C_M \leq 0$ and $C_H \leq 0$). The re-coding indicated in the lower left box in the figure is necessary because of a 1982 code change (WMO, 1988) that instructs observers to set C_L=C_M=C_H=/ when N=0 (this requires special attention in cloud type analysis and will be discussed in Section 4).

The number of reports that survive these tests and are suitable for total cloud analysis (referred to as "total reports") is 124.2 million for land and 14.7 million for ships. Of these, 90.3 million and 11.1 million, respectively, were made under sufficient solar or lunar illuminance (referred to as "light reports") to meet the established illuminance criterion for adequate cloud visibility (Hahn et al., 1994b).

1) Determination of Cloudiness at Night.

The ability of surface observers to adequately detect clouds at night has been questioned for many years (e.g. Riehl, 1947; Schneider et al., 1989). In an attempt to find a practical solution to this "night-detection-bias", Hahn et al. (1994b) analyzed ten years of nighttime data for the zone 0-50^{0} N and plotted reported cloud cover as a function of the illumination due to moonlight, which depends on the phase and altitude (angle above or below the horizon) of the moon and on the distance of the moon from the earth. The amount of total cloud reported at night increased as the lunar illuminance increased up to a certain threshold, after which the reported cloud cover leveled off. This threshold is referred to as "the illuminance criterion" and corresponds to the twilight produced by the sun at an altitude of about 9 degrees below the horizon. Thus the illuminance criterion is met when either the sun is at an altitude greater than -9^{o} or the position of the moon is such that its illuminance exceeds the threshold. These conditions were determined for each report with the use of an ephemeris and the latitude, longitude, date and time of the report.

This illuminance criterion was applied in analyses of total cloud cover and clear-sky frequency (Hahn et al., 1994a). (Fog and precipitation frequencies were also analyzed in that study but their detection does not depend on illumination). Application of the illuminance criterion increased the computed global average total cloud cover at night by about 4% and thus increased the daily average computed cloud cover by about 2%. Diurnal cycles of total cloud cover over land, which typically show daytime maxima, were reduced in amplitude when compared to previous studies which did not use the illuminance criterion (W86). Over the oceans, the increased computed nighttime cloud cover was often sufficient to result in nighttime maxima, in contrast to the daytime maxima previously reported (W88). Preliminary surveys conducted in conjunction with the present work suggest that we should expect similarly dramatic effects on analyses of middle and high clouds but little effect on low clouds.

Because of the importance of moonlight in the detection of clouds at night, parameters relating to the illuminance criterion are included in the edited cloud report (Section 4). Reports for which the illuminance criterion is met are referred to as "light reports", as opposed to "dark reports" (for which the criterion is not met) or "all reports" (which includes both light and dark).

C. Consistency Checks for Cloud Types and the Change Code

The reports that failed the cloud type consistency checks shown in Figure 1 were discarded. Other inconsistencies are possible which may be correctable or may provide cause simply to reject the report for cloud type analysis. As the synoptic reports were processed, any inconsistency encountered required a change to be made in the existing code before the report was entered into the edited cloud report archive. Any changes thus made are noted by assigning a "change code" (IC) to that report. This change code (with values 0 to 9) is preserved in the ECR (Section 4) so that modifications made to the original report can be identified.

Details of the cloud type processing following the total cloud stage shown in Figure 1 are presented in the form of the FORTRAN code in Table 3. Each segment of the table (delineated by a change code heading) describes the processing of a particular type of inconsistency or change. The changes associated with particular coded cases are described briefly in Table 4 along with the frequency of occurrence of each change type. (The changes referred to by IC=1 were discussed in section 3B.) Most of the inconsistencies under consideration have been discussed previously (W86, W88) but are summarized here.

For a report to provide useful cloud type information, both Nh and C_L must be given. If either is missing (and not correctable) then the report cannot be used for cloud type analysis and all cloud type variables are set to -1 for consistency (see segment IC_5 in Table 3). Thus if any inconsistency is discovered that cannot be corrected, simply setting Nh=-1 will result in exclusion of the report from cloud type analyses. For example, the IC_2,4 segment in Table 3 examines the case in which there is middle cloud but no low cloud. In such a case Nh should give the middle cloud amount. In some reports Nh was improperly set to 0 (W86). If there is also no high cloud then it must be that Nh=N and the report can be corrected (IC=2). But if high cloud is present, then the value of Nh is indeterminate, and set to -1 (IC=4), and the report cannot be used for cloud types (in such cases all cloud type variables are set to -1 in segment IC_5).

The situation is similar in segment IC_3,4. If only high cloud is present, Nh should properly be 0 but is sometimes given the value of N by an observer. This is readily corrected (IC=3). But if Nh<N in such a case, the report is irreconcilably inconsistent and must be rejected for cloud type analysis (set Nh=-1 and IC=4).

Segments IC_6 and IC_9 simply correct cases of sloppy reporting of middle and high clouds, such as reporting C_M=0 rather than C_M=/ when the sky is overcast with low cloud.

Segments IC_7 and IC_8 merely set C_M to represent our definition of Ns as a convenience for future cloud type analyses. As is usually the case, the original report can be reconstructed if desired.

The order in which some of these consistency checks is performed is also important to the outcome. For example, if segment IC_8 were performed before segment IC_6, then some cases of Ns would go undetected. Also, segment IC_9 must be performed after IC_8 for the same reason. However since it is not desirable to have the change code IC=8 overwritten by the relatively trivial change IC=9, this latter code is only entered in IC (although the change is made) if no previous change has been made (second part of segment IC_9 in Table 3). This co-occurrence of change codes should be rare since N is usually large when Ns is present.

From Table 4 we see that some change is made in 12% of land reports and 16% of ship reports, but that roughly half of the changes just represent classifying an observation as Ns, Cb or fog. Thus less than 5% of land reports and less than 9% of ship reports have been changed due to inconsistencies and most of these are due to the relatively trivial cases with IC=6 (and IC=9 for ships).

After passing the cloud type consistency checks, the number of light reports available for cloud type analysis for 1982-91 is 88 million for land and 9.4 million for the ocean (Table 5). Reports suitable for cloud type analysis (C_L and Nh > -1) are referred to as "type reports".

D. The Amounts of Upper Level Clouds

The synoptic code contains two cloud amount variables, N and Nh. The amount of low cloud, if present, is directly specified by Nh. While the amounts of upper level clouds are not directly specified, they may often be inferred. Thus when C_L=0, the amount of middle cloud is given by Nh, and when C_L=C_M=0, the amount of high cloud is given by N. If all three levels are present there are too few known variables to determine the upper cloud amounts. If two levels are present, the amount in the upper level may be estimated if the extent of overlap is assumed.

In the ECR we provide amounts that utilize the random overlap assumption, where necessary, in order to best represent the actual cloud amounts (the fraction of the sky covered by a cloud type, whether visible or not). We also provide the non-overlapped amounts which require no assumptions but which indicate only the amount of the upper level cloud visible from below. (Satellite-derived cloud amounts are typically given as the non-overlapped amounts visible from above.) Tian and Curry (1989) tested the minimum, maximum and random overlap assumptions and found the maximum overlap assumption to be best for adjacent cloud layers, while the random overlap assumption was best for vertically separated layers.

Table 6 gives our method, in the form of FORTRAN code, for determining the actual and non-overlapped amounts of middle and high clouds from a synoptic weather report. A few points should be noted. The random overlap equation (lines 17 and 38) is invoked only when Nh<7. Table 7, which gives the outcomes of the possible combinations of N and Nh in the equation, shows that only 2 outcomes are possible for the upper cloud amount when Nh=7, namely 0 and 8 oktas, making this a highly inaccurate determination (W86). In such cases the upper cloud amount is left undetermined. If the upper cloud in question is Ns, however, the maximum overlap assumption is employed and the Ns amount is assigned the value of N (lines 13-14, Table 6). In this case the nimbostratus cloud layer is likely to be adjacent to or continuous with the low cloud, so the maximum overlap assumption is more appropriate (Tian and Curry, 1989). Also, certain arbitrary decisions are sometimes required, such as our choice, in line 7 of Table 6, to allow middle cloud to be computed when C_H=/. This choice is justifiable since such a case tends to occur with large N so that any error induced by this situation would be small.

The number of times reports were processed through the possible paths in Table 6 are listed in Table 8. Light reports (for which the illuminance criterion was met) and dark reports (for which the illuminance criterion was not met) are both shown, where possible, for comparison. Land and ocean data were processed separately. Non-overlapped (NOL) amounts were computable in more than 90% of the cloud type reports since one can know that a cloud cannot be seen even if one does not know whether it is present. Thus the non-overlapped amount of an upper level cloud is frequently zero.

Percentages are not explicitly shown in the table but it can be seen that upper level clouds are reported more frequently in the set of light reports than in the set of dark reports (38% and 30%, respectively, for land middle clouds, and 44% and 29%, respectively, for ocean middle clouds, for example). When upper clouds are present, they are more frequently computable within the set of dark reports and random overlap (ROL) is less often required. Comparing land and ocean, upper level clouds, when observed to be present, are less likely to be computable from ocean data and are more likely to require ROL because of the predominance of low level clouds over the oceans. (The percentages given here merely represent the fractions of reports within the data set and are not area-weighted global averages.)

4. THE EDITED CLOUD REPORT AND THE DATA ARCHIVE

A. Contents and Format of the ECR

Table 9 shows the variables included in the ECR, the number of characters allocated for each, and the maximum and minimum values allowed. Each item in the table is discussed briefly below. Sample reports selected from ship and land data for 1981 December and 1982 January are provided in Table 10. These reports are in the order in which they appear in their respective files (see next section) though these selections are not consecutive within the file. The reports are numbered in the table for convenience.

Item 1: The first item in the report gives the year, month, day and GMT hour of the report, with 2 characters allotted for each. There are no spaces ("3", for example, is given as "03") so that the entire item can be read as a single integer. Only the last 2 digits of the year (1900's) are given. Months are coded as 1 through 12, representing January through December.

Item 2: The IB variable indicates whether the illuminance criterion of Hahn et al. (1994b) was satisfied (IB=1) at the time and place of the report or not (IB=0). This variable can be checked in lieu of SA and RI (items 19 and 20 below) if one accepts the criterion specified in Hahn et al.

Item 3: The latitude (in degrees north and south) is given to 2 decimal places and written as a 5-digit integer, and thus must be divided by 100 to obtain actual latitude. Actual values range from +90 to -90 for 90N to 90S, respectively.

Item 4: The longitude (in degrees east) is given to 2 decimal places and written as a 5-digit integer, and thus must be divided by 100 to obtain actual longitude. Actual values range from 0 to 360E.

Item 5: For land stations, ID is the WMO station number (WMO, 1977). For ships, ID is the card deck assignment (Slutz et al., 1985).

Item 6: This parameter indicates whether a report is from a land station (LO=1) or a ship (LO=2).

Items 7-13: These weather and cloud variables are coded as specified by WMO (1988) except that items 11 and 12 have been "extended" as described in Section 3A (Table 2). Also, cases of N=9 (item 8) that were not discarded have been converted to N=8. Any such conversion is coded in the "change code" (item 18 below). The value "-1" indicates missing data. Item 8 (N) does not obtain a value of -1 in this data set since all such reports were discarded during processing. Item 10 (h) may have a value of 9 only when a cloud is present since h was set to -1 in cases of N=0 (Figure 1).

Items 14-15: These variables give the "actual" cloud amounts of middle and high clouds and utilize the random overlap equation where necessary (Section 3D). Values are given in oktas to 2 decimal places and written as 3-digit integers, so they must be divided by 100 to obtain the actual values. An actual value of 9 (coded value 900) indicates missing data.

Items 16-17: These variables give the non-overlapped cloud amounts of middle and high clouds and represent the amount of cloud visible from below (Section 3D). Values are given in oktas. A value of 9 indicates missing data.

Item 18: The change code indicates whether a change was made to the original report during processing. Code values are defined briefly in Table 4 and in detail in Figure 1 and Table 3 (Section 3C). A change code of 0 means that no change was made other than the trivial change of converting /'s to 0's in the case of N=0. Examples of reports with each change code are provided in Table 10.

Items 19-20: These variables give the solar and lunar parameters needed to determine the illuminance provided by the sun or moon for the date, time and location of the report (Section 3B1). SA is the altitude of the sun above the horizon, given to a tenth of a degree (divide the coded value by 10 to obtain the actual value). RI is the lunar relative illuminance defined by Hahn et al., (1994b). RI= $\Phi \sin(A) (R^2/r^2)$, where A is the lunar altitude, r is the earth-moon distance, R is the mean earth-moon distance, and Φ is the lunar phase function which varies from 0 to 1 in a concave shape such that a full moon is 10 times as bright as a half moon (Hapke, 1971). The illuminance criterion of Hahn et al. (1994b) is met (IB=1, item 2) when $SA \geq -9^o$ or RI>0.11. (A negative value of RI means the moon was below the horizon.)

B. Organization of the Archive

The data are divided into 240 files, one for each month for ten years for land and ocean separately.

In the NMC data set archived at NCAR, the 6-hourly reports and 3-hourly reports (Section 2) are stored on separate files. Each of these subsets is sorted first by time and then by latitude and longitude. Each land data file of the ECRA was formed by writing the 6-hourly data first, followed by the 3-hourly data. The times were not merged. Thus for each month, the 6-hourly reports appear in time order from day one through the month and then the 3-hourly reports start again with day one and follow in time order through the month.

For the ship data, the sort used in COADS is retained in the ECRA. For each month this sort is first by 2-degree box, then by time, and finally by longitude and latitude.

5. COUNT SUMMARIES

A. Distribution of Reports over the 8 Synoptic Hours

Figure 1 and Tables 4, 5 and 8 showed the number of reports processed, deleted and changed, as well as the number of light reports, the number suitable for cloud type analysis, and the number of times upper level cloud amounts were computable. Table 11 shows how the reports are distributed over the synoptic reporting times. Land stations usually report 8 times per day but some do not (notably in the United States and Australia), so that 59% of all reports are made during the 6-hourly times. Ships, however, tend to report at the 6-hourly times and only about 10% of the ship reports are for the intermediate 3-hourly times. Having only 4 reports per day, rather than 8, limits the resolution possible in computations of the phase and amplitude of the diurnal cycle. It was also noted (W88) that regional averages formed from 6-hourly ship data may be uniformly different from averages formed from 3-hourly data, consistent with a tendency for some ships to give a 3-hourly report only in unusually stormy weather. A bias is also possible when averaging over a land grid box that has more than one station if stations within one climatic region report 8 times per day while stations within a different climatic region report 4 times per day.

B. Distribution of Code Values

The histograms in Figures 2a for land and 2b for ocean show the frequency of occurrence of the extended code values for the six cloud variables for light reports in the archive of edited cloud reports. [In these figures N=9 is shown separate from N=8 although N=9 appears as N=8 (with IC=1) in the ECR.] The shaded areas show the occurrence of precipitation (DRSTs, Table 2). Numerical values for the data shown in these figures are provided in Appendix A. Several interesting features are evident in these figures. The distribution of codes for total cloud cover N is nearly U-shaped for land but strongly skewed towards the higher amounts for oceans. 96.5% of all precipitation occurs with N≥7 over land and with N≥6 over oceans. About 75% of precipitation occurs with Nh≥6. The reports with Nh=-1 are not usable for cloud type analysis. The most commonly occurring cloud base height code is h=5 (600-1000m) over land and h=4 (300-600m) over oceans. The high frequency of h=9 over land is a consequence of the high occurrence of C_L=0 so that h=9 often refers to the middle cloud level.

The lower panels in Figures 2a and 2b show the occurrences of various cloud types within the three reporting levels. The occurrence of C_L=-1 is the same as Nh=-1 due to the processing procedure and is the fraction of reports that do not contain information relating to cloud types (2.6% for land data, 15.3% for ocean data). A larger fraction of the reports have

C_M=-1 (17.7% for land, 36.0% for ocean) and C_H=-1 (33.2% for land, 50.9% for ocean) because of lower overcast. Thus 97.4% of the land reports have information about cloud types but only 82% of those have information about the middle cloud level and 66% about high clouds. For the oceans, 84.7% of the reports have low cloud information but only 57% of those have middle cloud information and 40% have high cloud information.

The low cloud type most commonly reported over land is stratocumulus (C_L=5). While this type is also relatively common over the oceans, it is exceeded by the cumulus types C_L= 1 and 2. About 25% of all precipitation occurs with the stratus cloud C_L=7. When C_L=7 is reported over land, precipitation is present in 67% of the reports. Precipitation occurs in 34% of the ship reports of C_L=7.

While 58% (land) and 46% (ocean) of all precipitation occurs with the middle clouds defined to be nimbostratus (C_M= 10,11,12), 25% and 38%, respectively, of precipitation occurs when the middle cloud level is not given in the report (typically because of low overcast). Because of our definition of Ns shown in Table 2, most of these latter cases must have ww= D or Ts. In the high cloud level, 90% of all precipitation occurs in reports with C_H=-1 (high cloud level not reported, usually because of lower overcast).

C. Cases of Sky-obscured and Nimbostratus Cloud

The occurrence of reports of sky-obscured (N=9) due to fog or precipitation is 1.5% for land and 3.5% for ocean, with fog (C_L=11) accounting for more than two thirds of these values for both land and ocean (Figure 2 and Appendix A). These cases of sky-obscured due to fog make up 14% (land) and 48% (ocean) of all reported cases (light) of fog. Cases of thunderstorms or showers (C_L=10) account for only about 3.5% of the reports of sky obscured, and sky-obscured due to thunderstorms or showers make up only 1.6% (land) and 5.8% (ocean) of the light reports of thunderstorms and showers. The remaining contribution to the reports of sky obscured (about one quarter) is due to drizzle, rain or snow. Sky-obscured due to drizzle, rain or snow make up 5.1% (land) and 12.9% (ocean) of the light reports of drizzle, rain and snow.

A report of sky-obscured due to drizzle, rain or snow is considered to indicate nimbostratus cloud and is given the extended code value C_M=10 with IC=1 (Tables 2 and 4). Two other sets of circumstances are considered to indicate Ns as well. Table 12 shows the contributions of the three major paths to the frequency of Ns within the light type reports. (Frequencies based on light *type* reports are slightly higher than the frequencies quoted in the last paragraph which were based on the total set of light reports.) The largest contributor to

Ns in the land data is the path through C_M=2,7 (with ww=DRS). For both land and ocean C_M=2 is far more important than C_M=7 (see C_M=11,12 in Appendix A). The largest contributor to Ns in the ocean data comes through the C_M=/ path, which has several contributors itself, the largest being the case of C_L=7 with DRS.

Excluded from the definition of Ns are the cases of C_M=/ with C_L=4,5,6,8 and ww=D (more than half of these cases are due to C_L=6 alone). These cases were considered to indicate Ns in our previous climatologies (W86, W88) but after subsequent consideration and discussions with colleagues we concluded that since drizzle could occur from these low cloud types, the additional inference of Ns above them was inappropriate. Thus the frequencies of occurrence of Ns computed under the current definition will be reduced to about 97% (land) and 90% (ocean) of the frequencies given in W86 and W88.

Another change associated with the simplification of our previous definition of Ns involves cases of C_L=6,7 with DRS and C_M= other than 2,7,/. The C_L 6,7 in these cases were previously reassigned as Ns, but are left unchanged in the present, simplified definition. This results in a further reduction in computed Ns frequency by factors comparable to those in the last paragraph. Thus the ~~total~~ ~~reduction~~ ~~in~~ Ns frequencies computed under the present definition may be about 94% (land) and 81% (ocean) of those computed under the previous definition. Note that these percentages refer to the number of reports in the data set which contains a disproportionate contribution of reports from the densely populated northern mid-latitudes and thus do not represent the area-weighted global averages. Note also that the user of this data set is not restricted to the definitions assigned here since all the information necessary for any other interpretation is contained in the edited cloud reports. The definitions discussed above apply only if the reports are used exactly as written.

The cases of C_L=1,2,3,9 with C_L=/ and ww=DRS are not considered to indicate nimbostratus cloud.

D. Distribution of Reports over the Globe

To show the global distribution of the reports, numbers (shown as $\log_{10}$) of light type reports are displayed on a 5c grid (see Glossary in Appendix B) in Figures 3a (land) and 3b (ocean). Numbers from 1-9 appear as 0, numbers from 10-99 appear as 1, etc. Grid boxes with no light type reports are blank.

6. COMMENTS ON USE OF THE DATA

A. Biases

A number of biases which can affect analyses of clouds from surface observations are summarized in W88. Four biases which we can measure and possibly correct for are described in more detail here.

1) The Night-detection Bias and the Day-night Sampling Bias

The night-detection bias is largely eliminated by using only data for which the illuminance criterion is met (Section 3B1). This, however, enhances the day-night sampling bias unless precautions are taken since less than half as many nighttime observations will be available compared to the number of daytime observations. Thus Hahn et al. (1994a) prepared nighttime and daytime averages separately and averaged the two together to obtain the average cloud cover.

2) The Clear-sky Bias

Another potential bias for cloud type analyses was introduced by the synoptic code change in 1982 which allowed observers to record a "/" for cloud types when N=0. Previously a report with N=0 and C_L or Nh =/ would indicate a station that never reports cloud types and the report would be omitted from the cloud type analysis. Now every occurrence of N=0 must be treated as C_L=0 and Nh=0. Thus a report from a station or ship which never reports cloud types would contribute to a cloud type analysis only when the sky was clear, producing a clear-sky bias: the frequency of occurrence of clear sky computed from the cloud type reports would be too high and the frequencies of occurrence of the various cloud types would be too low. The magnitude of this bias can be estimated by counting the number of times observers within a grid box omit cloud types (Nh=/ or C_L=/) when N>0 and assuming that the same fraction of the cases of N=0 would be from stations or ships that do not report cloud types, and thus should be excluded from the denominator when determining the frequency of occurrence of a cloud type.

Figures 4a (land) and 4b (ocean) show the global distribution of the percent occurrence of C_L=/ (or Nh=/) in light reports with N>0 (this bias fraction is referred to as fb). (Note that when computing these fractions using the ECRA, reports of Nh=-1 with IC=4 must not be counted in fb since these values were set during data processing and not by the observer.) In the land data, extremely large values occur only in northern Alaska (87%, underlined in Figure 4a) and in northeast Greenland (72%). Ship data show large values in the Great Lakes region of North America where values exceed 90% and in some European waters where values are as great as 82%. Values of fb average about 3% for land data and about 10% for ship data.

To determine how much effect this bias would have on computed cloud type frequencies, the "clear-sky adjustment factor" (AF0) was defined such that $Fa = AF0 \cdot Fr$, where Fa is the adjusted frequency of occurrence of some cloud type and Fr is the frequency that would be computed using the potentially biased cloud type reports. Since $Fr = Nt / Nr$, where Nt is the number of occurrences of a particular cloud type and Nr is the number of reports contributing to the cloud type analysis, and $Fa = Nt / (Nr - fb \cdot N0)$, where N0 is the number of occurrences of N=0 and fb is the fraction of N0 that should be discounted, then, using $f0 = N0 / Nr$, Fa can be represented as $Fa = Nt / (Nr - fb \cdot f0 \cdot Nr) = Nt / (Nr \cdot (1 - fb \cdot f0)) = Fr / (1 - fb \cdot f0)$. Thus $AF0 = 1 / (1 - fb \cdot f0)$ and is equal to one if either fb or f0 is zero.

Figures 5a and 5b show the global distribution of AF0 {displayed as 100 x (AF0-1)} over land and ocean, respectively. This analysis shows that, on average, cloud type frequencies, if uncorrected, would be reduced only to about 99.5% of their correct values by this bias (average AF0 = 1.003 for land and 1.007 for ocean) and that most regions of the globe are essentially unaffected. However a few regions are greatly affected, namely northern Alaska, northeastern Greenland, the Great Lakes, and some seas around Europe. These are the regions with high values of fb (Figures 4a and 4b). The two most extreme regions, the Great Lakes and northern Alaska, have biased values 41% and 27% of their correct values. Other than the AF0 values of 3.68 in Alaska and 1.31 in Greenland, no land box has a value greater than 1.08. In the ocean data, moderate values of AF0 (around 1.10) occur in the Middle East where clear-sky frequencies are high (W88), and several higher values are seen in the seas of Europe and in the Great Lakes of North America. While it may be desirable to apply this adjustment factor to regions of moderately large AF0 values, practical application of this correction will be complicated by the fact that AF0 values vary from year to year, season to season, and day to night. Fortunately correction is unnecessary over most regions of the globe and the regions noted in Figures 5a and 5b for large adjustment factors can simply be eliminated from a cloud type analysis.

Note that while cloud type frequencies are subject to the clear-sky bias because of the coding instructions and practices for cloud type reports, the frequency of occurrence of clear sky itself (and also the frequency of fog) can be computed without this bias by using the total cloud data set to which this bias does not pertain (as was done in Hahn et al., 1994a).

3) The Sky-obscured Bias

Our recognition of certain cases of N=9 as overcast cloud (Section 3B) is important in obtaining accurate estimates of the amounts of fog and nimbostratus cloud, but may introduce the sky-obscured bias, which is similar in principle to the clear-sky bias discussed above. Since C_L=/ whenever N=9, it is not possible to distinguish stations or ships that normally report cloud types from those that do not. Thus the latter stations will contribute to the cloud type analysis only when the sky is obscured (aside from the case of clear sky which was discussed above). This will tend to cause the computed frequencies of fog and nimbostratus cloud to be too large and the frequencies of other cloud types to be reduced. The fraction fb shown in Figures 4a and 4b is again a measure of the potential of this bias. A "sky-obscured adjustment factor" (AF9) is defined in a manner similar to that for AF0 defined above such that $Fa = AF9 \cdot Fr$ and $AF9 = 1 / (1 - fb \cdot f9)$, where f9 is the frequency of occurrence of N=9 in cloud type reports.

The global distribution of f9 is given in Figures 6a and 6b. The box in northern Alaska (underlined), which was shown previously to have fb=0.87 (Figure 4a), also has the relatively large value of 0.16 for f9 which gives AF9=1.16. Inspection of Figures 4a and 6a together shows that this is the largest AF9 value for land data and that in most regions the value of AF9 is near 1.00. Ship data have larger fb values (Figure 4b) and larger f9 values (Figure 6b) than land data. Also the large values are distributed over larger regions. The largest f9 values occur, again, in the Great Lakes region where they combine with fb to produce AF9 values that approach 2. In the North Pacific, where large amounts of fog occur during the summer season (W88), moderately large f9 values (~0.20) occur with moderate fb values (~0.11), giving AF9=1.02 which is a relatively small bias. The global average values for AF9 are 1.0003 for land and 1.003 for the ocean. Thus, aside from the few regions specially noted to be removed from cloud type analysis, the sky-obscured bias is generally small. Any bias in the frequency of fog itself can be eliminated by computing it from the total cloud reports, as mentioned above. Any bias towards increasing the nimbostratus frequency will be small since N=9 contributes only a small portion of the total nimbostratus (Table 12) and will be compensated somewhat by the tendency towards reducing the frequency of Ns contributed by the C_M=2,7 and C_M=/ paths.

B. Computing the Average Cloud Amounts and Frequencies

The determination of the average cloud amounts and frequencies of occurrence from surface observations requires some special considerations to avoid various potential biases and to obtain representative values. Upper level clouds present special problems because they are sometimes partially or completely hidden from the view of the observer by lower clouds. These issues are discussed in detail in W86 and W88 but will be highlighted here.

1) Total Cloud Cover

Total cloud cover is basically the sum of the values of N in the synoptic code (converted to percent if desired) divided by the number of contributing reports. However, to avoid the day-night bias discussed above, some method of equalizing the contribution of reports between day and night is necessary. In W86, averages were obtained by first forming averages for the 8 synoptic hours and then averaging these 8 numbers. For oceans, where data are less plentiful, this method will result in significant loss of data because the 3-hourly times often do not have a sufficient number of reports to obtain a statistically reliable average. Therefore, Hahn et al. (1994a) divided the day into two 12-hour periods, 0600-1800 local time ("day") and 1800-0600 local time ("night"), and averaged these two numbers. Note that when using only the light reports (to avoid the night-detection bias) to form monthly averages, only about two weeks of data will contribute to the nighttime average in any single month. Due to this "monthly-sampling error" there will be more scatter in monthly averages from year to year although multi-year averages should become more statistically representative of climatological means as the number of contributing years is increased. Similarly, seasonal averages should be more representative of an individual season than monthly averages are of an individual month.

These considerations of the day-night bias, night-detection bias, and monthly-sampling error apply equally well to cloud type analyses discussed below. However, for quantities such as fog and precipitation, whose detection does not depend on illumination, all observations may be used, minimizing all three of these biases.

2) Low Cloud Types

Of the 90.3 million light reports suitable for total cloud analysis for land (Figure 1), 88.0 million have cloud type information (Table 5). For the ocean these numbers are 11.1 million and 9.4 million. In the type reports, the amount of a low cloud type (if present) is always given in the Nh variable of the report. The average amount for a particular low cloud type can be obtained, in a manner similar to that for total cloud amount, by summing the Nh values when the type is present and dividing by the number of contributing reports (using the precautions against the day-night bias discussed above and adjusting for the small clear-sky and sky-obscured biases if desired). The contributing reports consist of those with $C_L \geq 0$ and $Nh \geq 0$ and include reports of N=0. An alternative, but equivalent, method for obtaining the average is to compute the frequency of occurrence (f) of the type (the number of occurrences of the type divided by the number of contributing reports) and the amount-when-present (awp; sum of Nh's divided by the number of occurrences of the type) separately. Then the average amount is avg = f x awp. This latter method is described because it is often of interest to know the frequency of occurrence of a type in addition to its amount, because awp tends to be characteristic of a cloud type, and because this is the method used in computing upper level cloud type amounts.

3) Upper Level Clouds

Cloud type reports do not always contain information about upper level clouds because they may be hidden by an overcast or near-overcast layer of lower clouds. Thus, of the 88.0 million light type reports for land (Table 8), only 74.4 million have information about the middle cloud level ($C_M \geq 0$) and 60.3 million have information about the high level ($C_H \geq 0$). Of the 9.4 million light type reports for the oceans, 7.1 million have $C_M \geq 0$ and 5.5 million have $C_H \geq 0$.

The average amounts of upper level cloud types are obtained as described in the last section: avg = f x awp. Since we want the actual frequency of occurrence of a cloud type, and not just the frequency with which it is visible, f is computed as the number of times the type was observed divided by the number of reports of $C_U \geq 0$ (where C_U represents either C_M or C_H). For land, middle and high cloud frequencies are determined from 84.5% and 68.5% of the light type reports, respectively. For the oceans these values are 75.5% and 58.5%, respectively. The question of the degree to which these portions of the data set represent the whole data set for types is discussed in W86 and W88. Based on a study of the frequency of occurrence of As/Ac [f(As,Ac)] versus low cloud amount, Warren et al. (W88) applied an adjustment to f(As,Ac) which assigned to the cases of C_M=/ (15.5% of the type reports for land and 24.5% for ocean) a value that is the average of f(As,Ac) of the reports that have low cloud amounts of 3 to 7 oktas. For high clouds, f was computed only from reports with Nh<7 in order to reduce the partial-undercast bias (W88).

The amount-when-present of an upper cloud type can be determined, when it is reported present ($C_U > 0$), only if there are at most 2 cloud levels present. In addition, amounts are not computed for an upper cloud if it is undercast by a layer which covers 7 oktas or more of the sky (Section 3D). Therefore awp is computed from an even smaller pool of data than that used for frequency computations. Table 8 shows that, for land, 78% of the observed (light) occurrences of middle clouds and 75% of the observed occurrences of high clouds are computable. For the ocean data these values are 61% and 43%, respectively. Nevertheless, awp computed from these data is probably fairly representative of the actual awp (W86 and

W88) and any error in awp results in a smaller error in avg by the factor f. Any systematic error inherent in the random-overlap assumption would produce a smaller error in computed amounts since this assumption is used for only a fraction of the computable observations. Table 8 shows that the random-overlap assumption is used in 39% of the computable observations (light) of middle cloud and in 55% for high cloud over land. These fractions are larger for ocean data with random overlap used for 60% of the computable middle clouds and 70% of the computable high clouds.

Special note about Ns: Because Ns is defined on the basis of the occurrence of precipitation (Table 2) which does not depend on the visibility of the middle cloud level for its detection, its presence or absence is known for every type report. Thus the number of contributing reports for f(Ns) is the same as that for low cloud types ($C_L \geq 0$ and $Nh \geq 0$). However, when present, its amount is not always known and a separate tally (which will be different from that for the As/Ac clouds) must be kept for determining its awp.

7. HOW TO OBTAIN THE DATA

This documentation and the data described herein are available from:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, TN 37831-6335, U.S.A.
Telephone (615) 574-0390

or

Data Support Section
National Center for Atmospheric Research
Boulder, CO 80307, U.S.A.
Telephone (303) 497-1215.

The following citation should be used for referencing this archive and/or this documentation report:

Hahn, C.J., S.G. Warren, and J. London, 1994: *Edited Synoptic Cloud Reports from Ships and Land Stations Over the Globe, 1982-1991.* NDP026B, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN. (Also available from Data Support Section, National Center for Atmospheric Research, Boulder, CO.)

The archive of our earlier climatology (Hahn et al., 1988) and the accompanying atlases (Warren et al., 1986, 1988) are also available from the same sources listed above.

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Table 1. Cloud Information Contained in Synoptic Weather Reports

Symbol	Meaning	Codes*
N	total cloud cover	0-8 oktas 9= sky obscured
N_h	lower cloud amount	0-8 oktas
h	lower cloud base height	0-9
C_L	low cloud type	0-9
C_M	middle cloud type	0-9
C_H	high cloud type	0-9
ww	present weather	00-99
I_x	present weather indicator	1-6

* Any category for which information is lacking to the observer is coded as "/".

Table 2. Cloud and Weather Type Definitions Used

Level	Shorthand notation	Meaning	Synoptic codes	Extended codes#
	Tcc	total cloud cover	N = 0-9	0-8
	Clr	completely clear sky	N = 0	
	Ppt	precipitation	ww= 50-75,77,79,80-99	
	D	drizzle	50-59	
	R	rain	60-69	
	S	snow	70-75,77,79	
	Ts	thunderstorm, shower	80-99	
Low			C_L=	
	Fg	sky obscured by fog	/ with N=9 and ww=F*	11
	St	stratus	6,7	
	Sc	stratocumulus	4,5,8	
	Cu	cumulus	1,2	
	Cb	cumulonimbus	3,9, or N=9 with ww=Ts	10
Mid			C_M=	
	Ns	nimbostratus	2,7, or N=9, with ww=DRS / with ww=DRS and C_L=0,7 / with ww= RS and C_L=4-8	12,11,10 10 10
	As	altostratus	1; or 2,7 if not DRS	
	Ac	altocumulus	3,4,5,6,8,9	
High			C_H=	
	Cs	cirrostratus	5,6,7,8	
	Cic	cirrus, cirrocumulus	1,4,9	
	Cid	dense cirrus	2,3	

\# Extended codes shown where they differ from synoptic codes. In the extended code the value "-1", rather than "/", is used to signify missing information.

* F represents the fog codes ww=10-12,40-49.

Table 3. FORTRAN Code for Checking Cloud Type Consistencies
(All variables are integers. Cloud variables are defined in Table 1. Here DRS (Table 2) is "1" if true and "0" if false. IC is the Change Code (Table 4).)

```
c.IC_2,4--------------------- CORRECT MISCODED Nh with CM --------------
      IF (CM.GT.0 .AND. Nh.EQ.0 .AND. CL.EQ.0) THEN
        IF (CH.LE.0) THEN
          Nh = N
          IC = 2
        ELSE
          IC=4
          Nh= -1
        END IF
      END IF
      IF (CM.GT.0 .AND. Nh.LT.N .AND. CL.EQ.0.AND.CH.EQ.0) THEN
        IF (Nh.GE.0) IC=4
        Nh= -1
      END IF
c.IC_3,4--------------------- CORRECT MISCODED Nh with CH --------------
      IF (CH.GT.0 .AND. CM.EQ.0 .AND. CL.EQ.0) THEN
        IF (Nh.NE.0) THEN
          IF (Nh.EQ.N) THEN
            Nh=0
            IC = 3
          ELSE
            IF (Nh.GE.0) IC=4
            Nh=-1
          END IF
        END IF
      END IF
c.IC_4----------------------- EXCLUDE INCONSISTENCIES for TYPES --------
      IF (CL.GT.0 .AND. CM.EQ.0.AND.CH.EQ.0) THEN
        IF (Nh.LT.N .AND. N.NE.8) THEN
          IF (Nh.GE.0) IC=4
          Nh=-1
        END IF
      END IF
c.IC_5-----------------------
      IF (CL.LT.0 .OR. Nh.LT.0) THEN
        IF ((CM.GE.0 .OR. CH.GE.0) .AND. CL.LT.0) IC=5
        Nh=-1
        CL=-1
        CM=-1
        CH=-1
        h =-1
      END IF
c.IC_6----------------------- CORRECT MISCODED CM,CH 0->/ --------------
      IF (CH.EQ.0 .AND. CM.EQ.0 .AND.
     i   (N.EQ.8 .OR. (N.EQ.7.AND.N.EQ.Nh))) THEN
        CM=-1
        IC=6
      END IF
      IF (CH.EQ.0 .AND.
     i   (N.EQ.8 .OR. (N.EQ.7.AND.N.EQ.Nh))) THEN
        CH=-1
        IC=6
      END IF
c.IC_7----------------------- RESET Ns FROM CM 2,7 ---------------------
      IF (DRS.EQ.1 .AND. (CM.EQ.2 .OR. CM.EQ.7)) THEN
        IF (CM.EQ.2) CM=12
        IF (CM.EQ.7) CM=11
        IC = 7
      END IF
c.IC_8----------------------- SET Ns FROM CM/ --------------------------
      IF (DRS.EQ.1 .AND. CM.LT.0 .AND. CL.GE.0) THEN
        IF (.NOT.(CL.EQ.1 .OR.CL.EQ.2 .OR.CL.EQ.3 .OR.CL.EQ.9)) THEN
          IF (ww.GE.60 .OR. CL.EQ.7 .OR. CL.EQ.0) THEN
            CM =10
            IC = 8
          END IF
        END IF
      END IF
c.IC_9----------------------- CORRECT MISCODED CM,CH /->0 --------------
      IF (CM.LT.0 .AND. CH.GE.0 .AND. CL.GE.0) THEN
        CM=0
        IF (IC.EQ.0) IC=9
      END IF
      IF (N.LE.4 .AND. N.EQ.Nh .AND. CL.GE.0) THEN
        IF ((CM.LT.0 .OR. CH.LT.0).AND.IC.EQ.0) IC=9
        IF (CM.LT.0) CM=0
        IF (CH.LT.0) CH=0
      END IF
```

Table 4. Change Codes for Edited Cloud Reports

			Occurrence (%)			
			Land		Ocean	
IC*	Case (brief description**)	Changes made#	all	light	all	light
0		none##	88.2	88.2	84.4	84.2
1	N=9 with ppt or fog	N=8; CL=10,11 or CM=10	1.5	1.5	3.7	3.5
2	Nh=0 with CM>0 and CL=0	Nh=N	0.2	0.2	0.1	0.1
3	Nh=N with CH>0 and CL=CM=0	Nh=0	0.1	0.1	0.3	0.4
4	Nh<N where should be Nh=N	Nh=/	0.4	0.4	0.9	0.9
5	CL =/ with CM or CH	CM,CH =/	0.1	0.1	0.7	0.7
6	CM or CH miscoded as 0	CM or CH =/	3.2	3.5	4.0	4.4
7	CM=7,2 for Ns	CM=11,12	3.7	3.5	1.3	1.4
8	CM=/ for Ns	CM=10	2.4	2.2	1.9	2.0
9	CM or CH miscoded as /	CM or CH =0	0.3	0.3	2.7	2.4

* Also order in which changes made. IC=9 is recorded only if no previous change (possibly 7 or 8) occurred.

** See Table 3 for details.

The value "-1" is used to signify "/".

Cases of N=0 for which Nh=CL=CM=CH=/ were set to 0 were not considered to be changes.

Table 5. Number of Reports with Cloud Type Information (Nh > -1, CL > -1)

	Land	Ocean
all reports	121 million	12.1 million
light reports	88 million	9.4 million

Table 6. FORTRAN Code for Determining Upper Level Cloud Amounts

```
*jum,juh are middle and high cloud non-overlapped amounts in octa (9=missing).
*AM,AH are "actual" amounts with possible use of random overlap.
*JAM,JAH are integer values of AM,AH to 2 decimal places for ECR (900=missing).
*  Other variables are integers. Cloud variables are defined in Table 1.
      jum= 9
      juh= 9
      JAM=900
      JAH=900
      if (CL.ge.0 .and. Nh.ge.0)  then
c_MID------------------------------------------------------------------------
      IF (CM.GT.0) THEN
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . present
        IF (CL.EQ.0 .OR. CH.LE.0) THEN
          IF (CL.EQ.0) THEN
            jum= Nh
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable
            JAM= Nh*100
          ELSE
            jum=(N-Nh)
            IF (CM.LE.12 .AND. CM.GE.10) THEN
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Ns computable
              JAM= N*100
            ELSE
              IF (Nh.LT.7) THEN
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable,ROL
                AM= 8.*(N-Nh) / (8.-Nh)
                JAM= AM*100. +.5
              END IF
            END IF
          END IF
        ELSE
          IF (Nh.EQ.N) jum=0
        END IF
      ELSE IF (CM.EQ.0) THEN
        JAM=0
        jum=0
      ELSE
        IF (Nh.EQ.N .AND. CL.GT.0) jum=0
      END IF
c_HI-------------------------------------------------------------------------
      IF (CH.GT.0) THEN
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . present
        IF (CL.EQ.0 .AND. CM.EQ.0) THEN
          juh= N
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable
          JAH= N*100
        ELSE IF (CL.EQ.0 .OR. CM.EQ.0) THEN
          juh= (N-Nh)
          IF (Nh.LT.7) THEN
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable,ROL
            AH= 8.*(N-Nh) / (8.-Nh)
            JAH= AH*100. +.5
          END IF
        ELSE
          IF (Nh.EQ.N) juh=0
        END IF
      ELSE IF (CH.EQ.0) THEN
        JAH=0
        juh=0
      ELSE
        IF (Nh.EQ.N .OR. (CL.GT.0 .AND. CM.GT.0)) juh=0
      END IF
      end if
```

Table 7. RANDOM OVERLAP COMPUTATION TABLE

(For upper level cloud amount when 2 and only 2 levels present)

Amount Upper Cloud [octa] = 8. * (N - Nh) / (8. - Nh)

N\Nh	7	6	5	4	3	2	1	0
8	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
7	0	4.00	5.33	6.00	6.40	6.67	6.86	7.00
6	x	0	2.67	4.00	4.80	5.33	5.71	6.00
5	x	x	0	2.00	3.20	4.00	5.57	5.00
4	x	x	x	0	1.60	2.67	3.43	4.00
3	x	x	x	x	0	1.33	2.29	3.00
2	x	x	x	x	x	0	1.14	2.00
1	x	x	x	x	x	x	0	1.00

Table 8. Number of Reports in which Upper Level Cloud Amounts were Computable
(millions of reports)

	LAND				SHIPS			
	Middle Cloud		High Cloud		Middle Cloud		High Cloud	
Number of:	Light	Dark	Light	Dark	Light	Dark	Light	Dark
Type reports	88.0	33.0	88.0	33.0	9.4	2.7	9.4	2.7
NOL* computed	81.2	31.7	81.1	31.7	8.4	2.5	8.4	2.5
Level reported	74.7	#	60.3	#	7.1	#	5.5	#
Cloud observed	33.0	10.0	27.6	6.5	4.1	0.8	2.3	0.8
Computable	25.7	8.7	20.7	5.3	2.5	0.6	1.0	0.15
ROL* used	10.1	2.4	11.3	2.3	1.5	0.3	0.7	0.10

* NOL signifies non-overlapped amounts and ROL signifies the random overlap assumption.

Data not available.

Table 9. Contents and Format of the 56-character EDITED CLOUD REPORT

Item	Description	Abbreviation	Number of characters	Minimum value	Maximum value
1	year,month,day,hour	yr,mn,dy,hr	8	81120100	91113023
2	sky brightness indicator	IB	1	0	1
3	latitude x100	LAT	5	-9000	9000
4	longitude x100	LON	5	0	36000
5	station number(land) or source deck(ships)	ID	5	01000 110	98999 999
6	land/ocean indicator	LO	1	1	2
7	present weather	ww	2	-1	99
8	total cloud cover	N	1	0	8#
9	lower cloud amount	Nh	2	-1	8
10	lower cloud base height	h	2	-1	9
11	low cloud type	CL	2	-1	11#
12	middle cloud type	CM	2	-1	12#
13	high cloud type	CH	2	-1	9
14	middle cloud amount* x100	AM	3	0	900
15	high cloud amount* x100	AH	3	0	900
	non-overlapped amounts:*				
16	middle cloud amount	UM	1	0	9
17	high cloud amount	UH	1	0	9
18	change code	IC	2	0	9
19	solar altitude (deg x10)	SA	4	-900	900
20	relative lunar illuminance x100	RI	4	-110	117

Cases of sky-obscured (N=9) due to fog (ww 10-12,40-49), thunderstorms (ww 80-99) or drizzle/rain/snow (ww 50-75,77,79) have been converted to N=8 and CL=11 (fog) or CL=10 (thunderstorms) or CM=10 (Ns). Certain cases of CM=/ with drizzle/rain/snow have been converted to CM=10 also. Cases of CM=2,7 with drizzle/rain/snow have been converted to CM=12,11, respectively, to indicate Ns. Changes are coded in the IC parameter.

* Upper level cloud type amounts can be computed only when 2 or less levels are present. AM and AH come from Nh, N, or the random-overlap equation and represent "actual" cloud amount. UM and UH are the amounts visible (the non-overlapped amounts) and come from Nh, N, or N-Nh. [Amounts are given in octa, AM and AH to two decimal places.]

Table 10. Sample Edited Cloud Reports in 56-character Format

	I		L uu	I		
	YrMnDyHrB	Lat Lon	IdOwwNNh hClCmCh Am AhMH	C	SA	RI
Ship:						
(1)	811205060	674030580	8902758 8 0 010-180090080	1	-391	-4
(2)	811224180	5810 140	8882618-1-1-1-1-190090099	0	-204	0
(3)	811230181	586021640	9272 37 6 3 6 6-140090010	0	-31	-1
(4)	811209181	5510 600	8902857-1-1-1-1-190090099	0	-230	31
(5)	811203001	541019970	9262 36 6 2 7 1-1 090000	0	114	0
(6)	811218120	514017160	9272683 3 3 710 0300 000	8	-613	-1
(7)	811220121	500035790	8902 28 8 3 5 2-190090000	0	165	0
(8)	811204000	498029810	9262458 8 011-1-190090000	1	-363	2
(9)	811207181	468031380	8902468 8 9 0 1-180090080	6	91	3
(10)	811224121	428031810	8902804 2 0 0 8 520026722	0	134	0
(11)	811210001	398014250	8902 27 7 5 5 2-190090000	6	190	-38
(12)	811225060	397023360	8902463-1-1-1-1-190090099	5	-552	0
(13)	811224001	369014160	8882 14 0 9 0 0 6 040004	3	197	0
(14)	811219151	360034550	9262 25 4 3 3 2-120090010	0	236	-1
(15)	811216120	355014110	8902 00 0-1 0 0 0 0 000	0	-551	-3
(16)	811224061	349016210	9262 28 7 4 5 2-190090010	0	1	0
(17)	811209001	332016430	8902 38 8 4 7 8 190090000	0	324	-33
(18)	811221050	332033690	9272 12-1-1-1-1-190090099	4	-433	0
(19)	811224120	245013560	9262508 8 3 4-1-190090000	0	-496	0
(20)	811205001	250023650	9262 27 7 4 8 9 390090000	0	158	6
(21)	811221181	244028980	9262 56 4 5 8 3-140090020	0	382	0
(22)	811211181	218027640	9272 22 2 3 1 0 0 0 000	9	444	-72
(23)	811210121	143011600	8902 28 1 3 1 0 5 080007	0	-308	58
(24)	811222181	121026940	9272 23-1-1-1-1-190090099	4	544	0
(25)	811230120	-47911170	8902807 3 4 3 7-164090040	0	-172	0
(26)	811205180	-78911830	9262 28 3 3 6 1-180090050	0	-473	-3
(27)	811221121	-123932380	8902508 8 4 9-1-190090000	0	543	1
(28)	811201181	-163934780	8902 26 6 7 0 5 0600 060	2	145	1
(29)	811218061	-2069 1280	8902 27 7 4 5-1-190090000	6	200	7
(30)	811209001	-2239 780	8902168 8 3 9 7-190090000	0	-438	29
(31)	811226121	-238931790	9262 38 6 6 4 7-180090020	0	514	0
(32)	811213181	-3519 1940	8882 38 8 5 6 5-190090000	6	-23	-21
(33)	811217001	-351927230	8902 27 6 6 5-1-190090099	0	106	-13
(34)	811201181	-395930100	8902 56-1-1-1-1-190090099	4	563	1
(35)	820104180	448014800	8902638 8 5 712-180090000	7	-391	-6
Land:						
(36)	820102180	4110126155	43771498 8 011-1-190090000	1	-554	-4
(37)	820103121	6112 907	13711-11-1-1-1-1-190090099	0	58	0
(38)	820110181	-2087 5552	619801-14 1 5 8 3 290090099	0	-343	34
(39)	820109031	1843290337	84851-17 4 5 2 3 0600 030	0	-649	89
(40)	820122091	6028 522	13111618 7 4 712-180090010	7	28	0

Table 11. Distribution of Reports over the Synoptic Reporting Times

	Total Number	00	03	06	09	12	15	18	21	6-hr	3-hr
		Percent of reports at reporting times (GMT)									
LAND											
all reports	124,164,607	14.4	9.4	14.6	11.4	15.7	10.3	14.4	9.8	59.1	40.9
light reports	90,348,885	12.6	9.6	17.6	14.7	17.3	10.3	11.3	6.6	58.8	41.2
cloud type rpts (light)	87,982,297	12.6	9.7	17.6	14.6	17.3	10.3	11.3	6.6	58.8	41.2
SHIP											
all reports	14,721,941	22.7	2.6	22.4	2.8	22.6	2.9	21.7	2.3	89.4	10.6
light reports	11,093,710	22.0	2.2	21.1	3.0	22.9	3.4	23.2	2.2	89.3	10.7
cloud type rpts (light)	9,400,201	22.5	2.1	21.8	2.8	22.8	2.9	23.0	2.1	90.1	9.9

Table 12. Contribution of the Various Paths to Total Nimbostratus Frequency

		LAND 88 million light type reports		OCEAN 9.4 million light type reports	
Path to Ns	ww	frequency Ns,%	percent of Ns	frequency Ns,%	percent of Ns
Total		6.24		4.90	
CM=2,7	D,R,S	3.59	58	1.60	33
N=9	D,R,S	0.39	6	0.96	19
CM=/:		2.26	36	2.34	48
CL=7	D,R,S		(17)*		(26)
CL=0	D,R,S		(.1)		(.02)
CL=6	R,S		(5)		(12)
CL=4,5,8	R,S		(14)		(10)
Exclusions*:					
CL=4,5,6,8	D	~0.2		~0.6	
CL=1,2,3,9	D,R,S	~0.08		~0.3	

* Approximate values based on January data: for exclusions and values in parentheses.

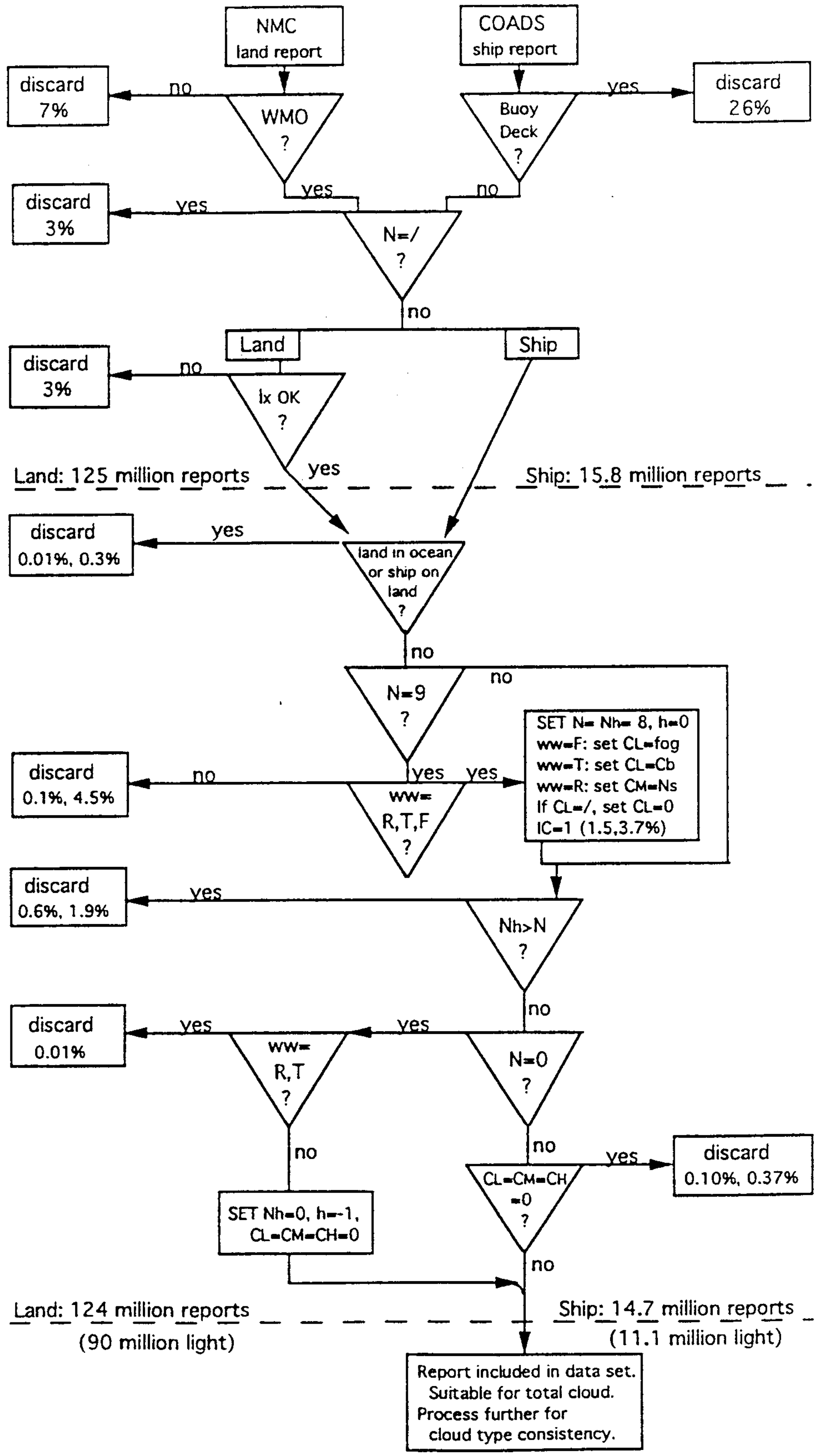

Figure 1. Flow chart of report processing through the total cloud stage. (Discard percentages given in order: land, ships. T and R here abbreviate Ts and DRS of Table 2. Other symbols are defined in Tables 1 and 2 except IC is defined in Table 4.)

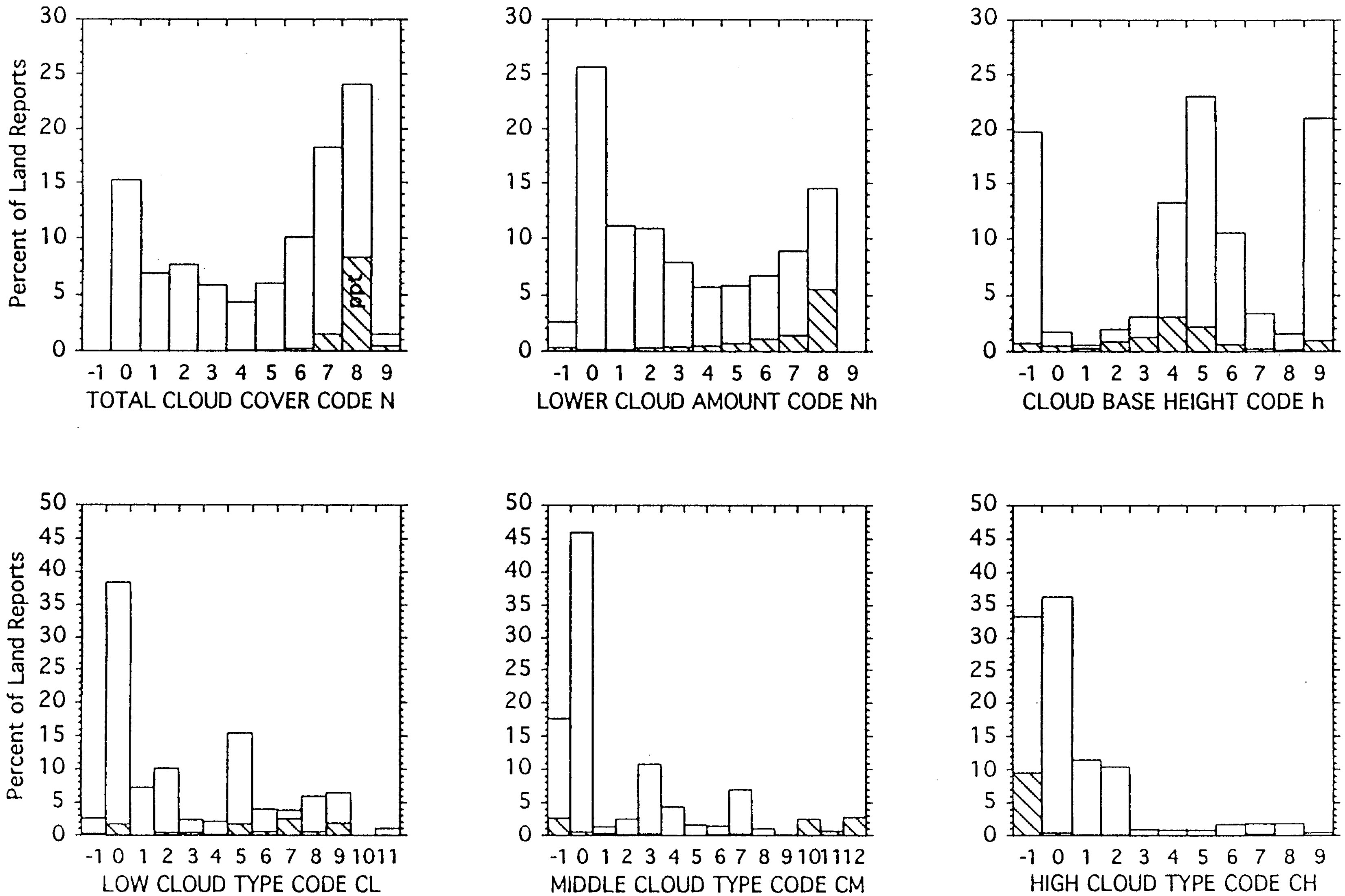

Figure 2a. Frequency distribution of extended code values for indicated cloud variables in edited light reports from land stations over the globe for 1982-1991. Shaded areas indicate occurrence of precipitation. (N=9 is relabled as N=8 in the ECR.)

e

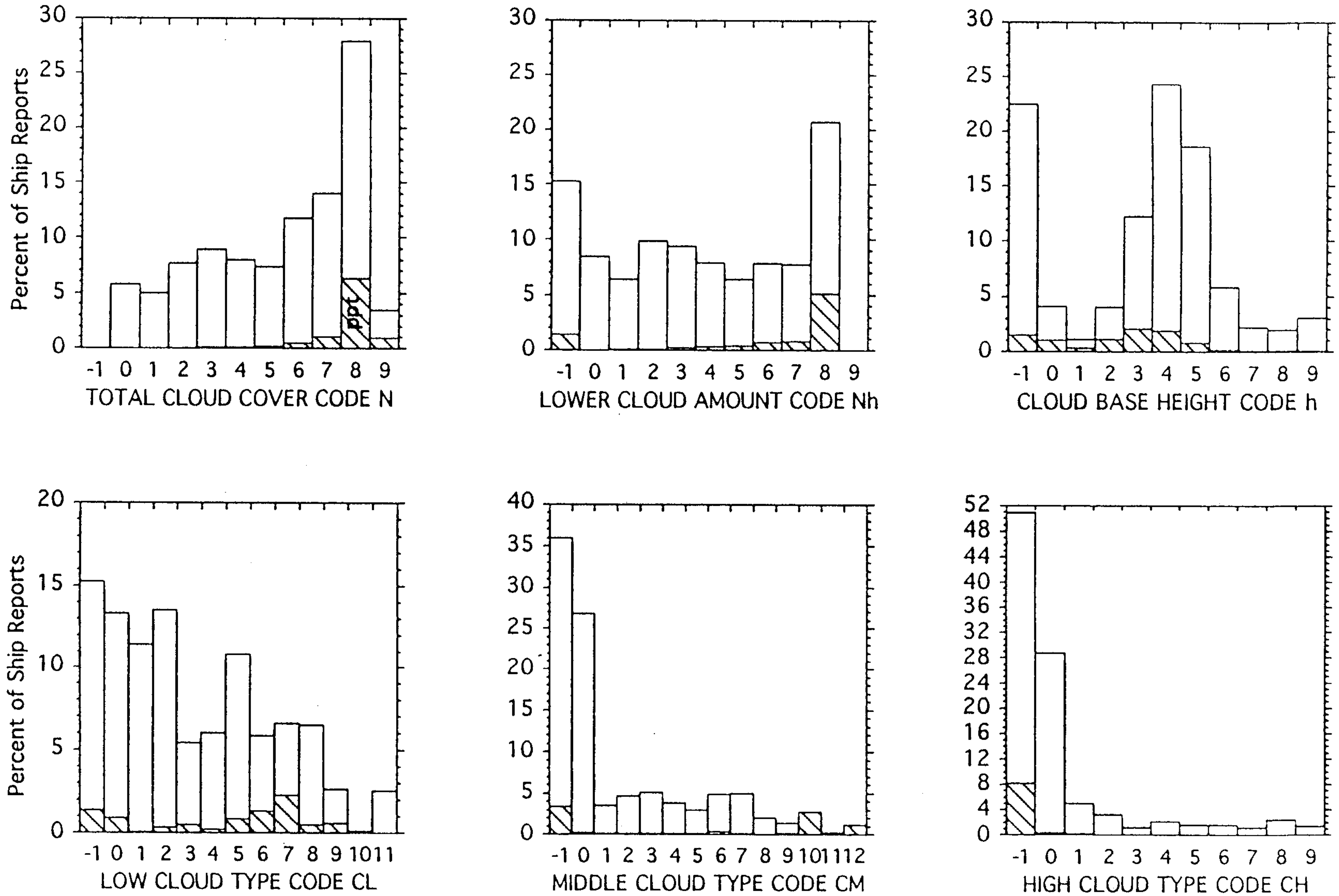

Figure 2b. Frequency distribution of extended code values for indicated cloud variables in edited light reports from ships over the globe for 1982-1991. Shaded areas indicate occurrence of precipitation. (N=9 is relabled as N=8 in the ECR.)

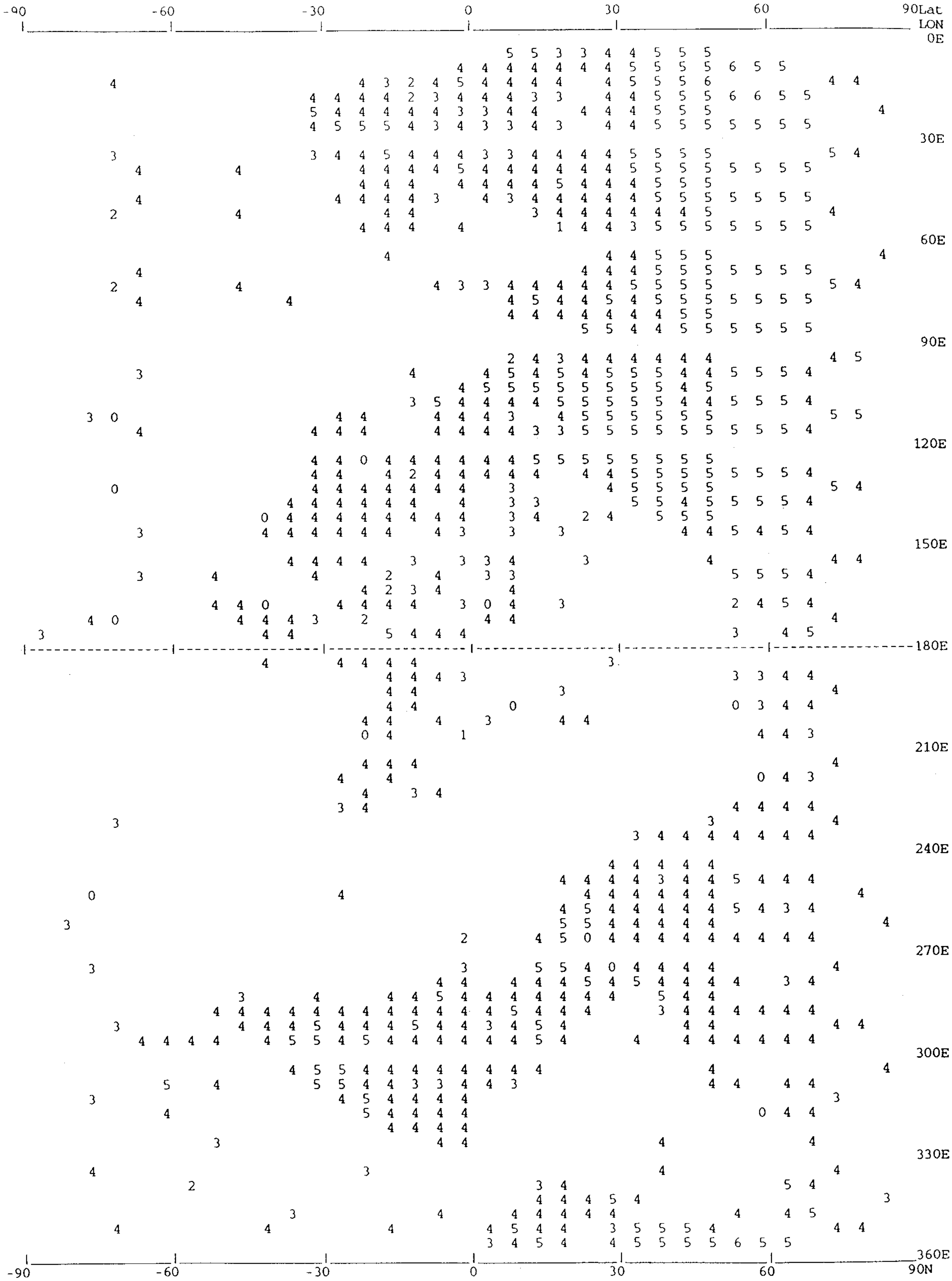

Figure 3a. Global distribution of log(number) of light reports for cloud types for 1982-1991 land data. 87,982,297 reports in 860 5x5^{o} grid boxes (see Glossary: "5c grid"). Blank indicates no reports.

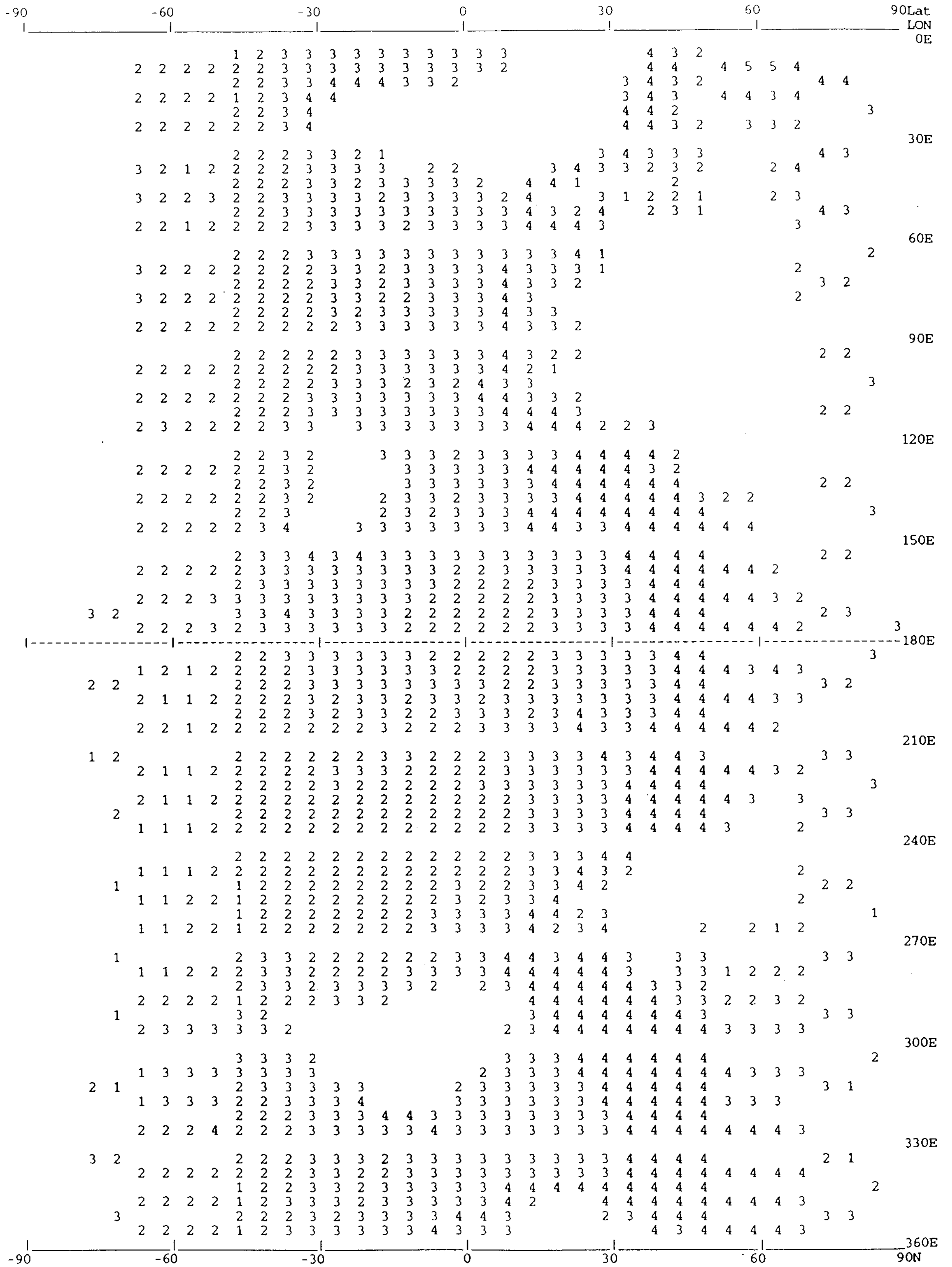

Figure 3b. Global distribution of log(number) of light reports for cloud types for 1982-1991 ship data. 9,400,201 reports in 1502 5x5^{o} grid boxes (see Glossary: "5c grid"). Blank indicates no reports.

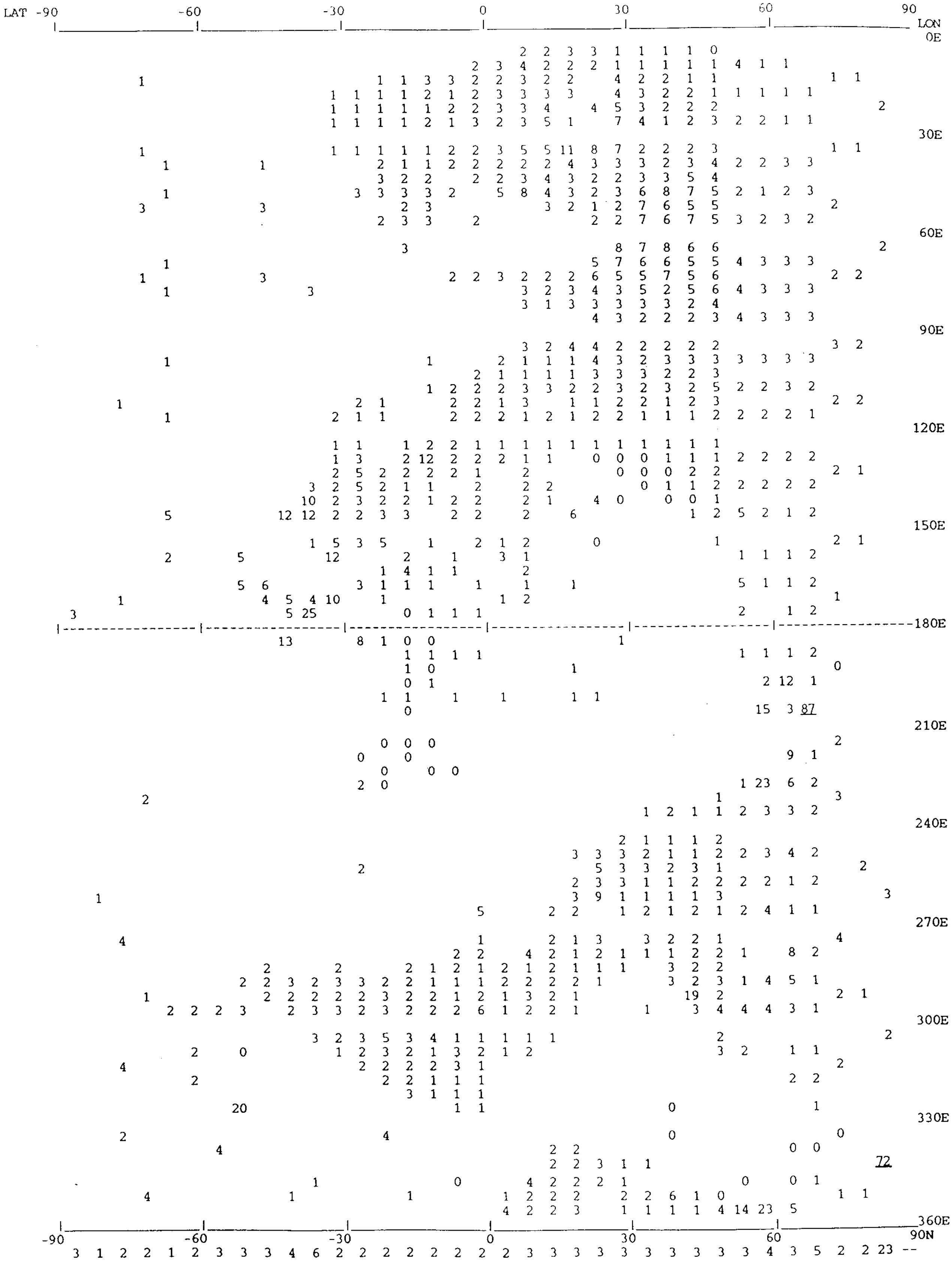

Figure 4a. Global distribution of occurrence of CL=/ or Nh=/ with N>0 (fb) in light reports for 1982-1991 land data (%). Global average for 843 5c-grid boxes with 50 or more reports is 2.7%.

LON	-90						-60						-30						0						30						60					
0E									3	10	9	9	6	7	6	7	9	9	13	16						13	14	31								
					3	5	7	9	11	13	9	8	7	7	8	9	9	10	12	16						11	11		43	26	15	4				
									6	8	8	8	8	10	10	12	13	11				18			13	12	12	12					9	6		
					5	7	4	2	3	5	9	9	14												12	13	38		47	38	72	10				
									7	4	8	9													12	29	25								5	
					2	9	7	5	4	8	11	9													11	22	11	11		31	74	82				
30E									7	3	11	11	8	10	8									16	10	14	11	6					6	6		
					2	4	9	5	12	9	13	9	10	9	8		4	8				14	15	14	5	19	12	17			11	7				
									7	4	9	7	9	11	8	9	8	10	11		13	15	17				10									
					4	4	8	4	7	15	8	11	9	8	10	9	9	7	11	13	11			27	18						12	10				
									7	15	7	9	8	9	8	10	10	8	7	10	11	10	12	17									6	8		
					5	4	9	4	5	8	10	9	8	9	10	9	7	9	10	12	9	9	13	17								7				
60E									13	13	12	7	9	9	8	10	8	5	12	9	8	8	10	24											6	
					4	4	7	7	10	10	10	9	8	6	9	7	8	8	9	9	8	9	9	10								19				
									8	7	8	8	8	8	10	8	5	8	10	10	10	11	16										6	5		
					3	3	10	12	5	8	8	6	7	8	9	9	7	7	11	11	13											23				
									4	5	9	8	7	6	8	7	7	7	10	9	12	14														
					3	3	4	3	6	5	7	8	7	7	8	7	5	7	7	7	10	12	13													
90E									5	8	6	9	6	7	7	6	7	8	6	7	12	11	11										8	9		
					3	3	5	5	9	4	4	10	6	6	6	7	7	7	8	7	9	19														
									9	5	5	9	7	5	7	12	8	11	10	7	7														3	
					18	39	47	21	14	9	7	8	6	6	9	9	10	10	9	7	7	10	8													
									11	6	8	8	10	14	11	8	10	8	15	8	7	7	7										13	14		
					51	48	32	12	5	6	9	8		21	15	11	7	7	7	11	8	8	9	8	17	9										
120E									2	4	8	11			28	13	7	6	11	9	8	9	9	11	8	8	8									
					59	48	8	5	4	6	8	12				20	12	12	8	6	5	6	9	10	11	11	18									
									8	6	9	15				35	12	13	10	6	5	5	5	7	10	18	13						10	11		
					12	11	16	8	5	6	10	20			26	21	13	13	6	8	8	6	4	5	10	19	13	12	14	9						
									4	17	14				26	24	29	13	12	9	5	4	5	8	8	12	13	11							6	
					6	5	15	15	14	18	38			19	20	20	15	13	7	6	5	6	6	8	8	10	10	8	8	8						
150E									10	9	12	12	14	12	10	10	10	8	7	7	7	6	8	9	8	9	12	8					12	9		
					13	3	8	10	4	8	8	8	8	9	12	10	13	9	8	8	12	7	7	9	8	9	12	10	7	8	7					
									7	7	7	8	8	8	11	10	11	18	10	12	12	6	7	8	9	8	11	11								
					5	5	6	7	10	10	7	7	8	10	9	13	14	10	13	19	15	6	7	7	9	9	11	11	10	5	6	11				
			1	3					5	14	9	9	7	9	8	7	16	12	15	14	11	6	7	7	9	9	11	11					10	2		
					5	6	7	4	6	11	11	5	4	5	6	12	10	12	14	18	9	8	6	6	8	9	10	11	13	5	5	8				6
180E									4	14	5	6	8	5	6	8	9	11	12	14	10	7	6	7	10	9	10	12							2	
					5	2	6	4	6	11	7	5	5	6	7	6	9	10	14	15	11	7	6	7	9	9	10	11	13	6	5	6				
			4	5					5	8	7	6	5	6	7	6	6	7	9	9	14	8	6	8	11	9	11	13					3	2		
					3	7	4	8	8	14	7	5	6	5	5	8	6	6	9	9	9	9	6	9	11	10	10	13	14	4	5	5				
									9	11	11	6	9	7	5	13	8	7	7	9	7	8	6	8	10	10	10	14								
					2	7	8	9	8	13	9	10	10	9	7	7	6	10	7	9	10	9	5	7	11	10	11	14	14	8	12					
210E			5	5					3	12	9	8	8	9	11	8	9	6	6	8	7	11	8	6	10	11	11	16					3	3		
					3	3	4	5	4	8	19	11	12	12	9	7	6	6	4	9	8	10	10	7	9	10	11	16	15	7	13	4				
									6	8	10	15	11	10	7	6	5	13	6	8	10	8	9	7	8	11	11	15							3	
					3		1	6	6	9	17	11	10	9	6	9	8	8	8	8	8	9	7	8	9	10	11	14	12	8		23				
				3					6	12	8	7	13	11	9	9	6	6	10	12	11	9	11	7	9	10	9	14					3	4		
					4		11	13	6	7	6	8	13	8	12	10	7	6	11	12	13	11	8	9	11	14	12	12	15			74				
240E									7	5	6	9	13	9	8	8	6	8	12	14	8	10	8	11	11											
					10	2	4	6	5	7	5	4	13	9	6	6	5	9	7	13	12	11	12	14	19							17				
				1					7	8	7	7	18	14	9	8	8	9	8	14	10	11	12	19									8	4		
					2		4	5	6	9	11	7	10	15	7	8	9	9	10	10	10	11										11				
									8	4	10	12	12	9	7	10	9	8	8	11	11	11	39	16											24	
					3	6	3	7	14	6	6	6	11	12	14	11	8	7	9	10	9	10	11	9						56	80	6				
270E									10	5	7	10	10	9	14	9	8	6	8	9	12	6	6	8	10								8	6		
					1	10	3	8	8	8	8	10	9	10	10	13	11	11	10	9	5	6	9	12	17		96	95	45	41	36	26				
									10	5	6	11	9	9	10	10	11		9	11	8	7	9	10	17	19	90									
					2	6	5	8	5	9	14	11	8	9	13						10	9	9	9	10	20	30	87	53	52	33	22				
				4					10	13											9	9	9	9	10	13	48	81					14	10		
					3	3	8	9	10	9	12									15	8	10	11	14	11	11	29	69	80	22	20	16				
300E									10	12	10	10								11	9	10	11	13	12	11	9	48							42	
						6	7	9	8	10	14	13							16	10	11	11	12	12	13	12	15	24	32	18	35	50				
			1						11	10	9	13	13	17				13	10	9	11	11	11	12	13	12	14	9					20	33		
					7	7	5	7	15	8	8	8	13	15				12	10	11	13	13	11	12	13	12	13	15	21	27	36					
									7	11	10	8	10	12	13	13	20	12	10	13	10	12	13	13	12	13	13	13								
					4	2	6	8	6	9	12	10	10	14	12	10	12	12	14	11	12	13	13	12	13	13	13	12	6	21	25	57				
330E			2	2					6	10	9	12	10	8	16	10	7	10	13	15	14	15	14	12	11	13	12	11					20	17		
					2	2	5	9	6	12	13	9	10	10	8	8	9	9	11	13	16	16	15	12	10	12	13	10	11	9	37	44				
									5	9	9	9	10	13	6	8	10	7	9	15	17	17	17	13	11	10	14	9							7	
					1	3	7	10	20	15	22	9	8	6	7	5	10	19	9	15	22			14	12	11	13	12	15	13	58	50				
				2					10	40	12	9	9	5	7	5	9	9	14	16				23	14	14	14	13					8	6		
					3	4	9	20	14	15	12	9	6	6	6	7	7	10	14	13						13	19	16	23	31	50	15				
360E																																				
90N	--	--	3	3	5	9	8	8	8	9	9	9	9	9	9	10	9	9	10	10	10	9	9	9	10	12	13	14	15	17	31	23	8	6	8	6

Figure 4b. Global distribution of occurrence of CL=/ or Nh=/ with N>0 (fb) in light reports for 1982-1991 ship data (%). Global average for 1487 5c-grid boxes with 50 or more reports is 9.7%.

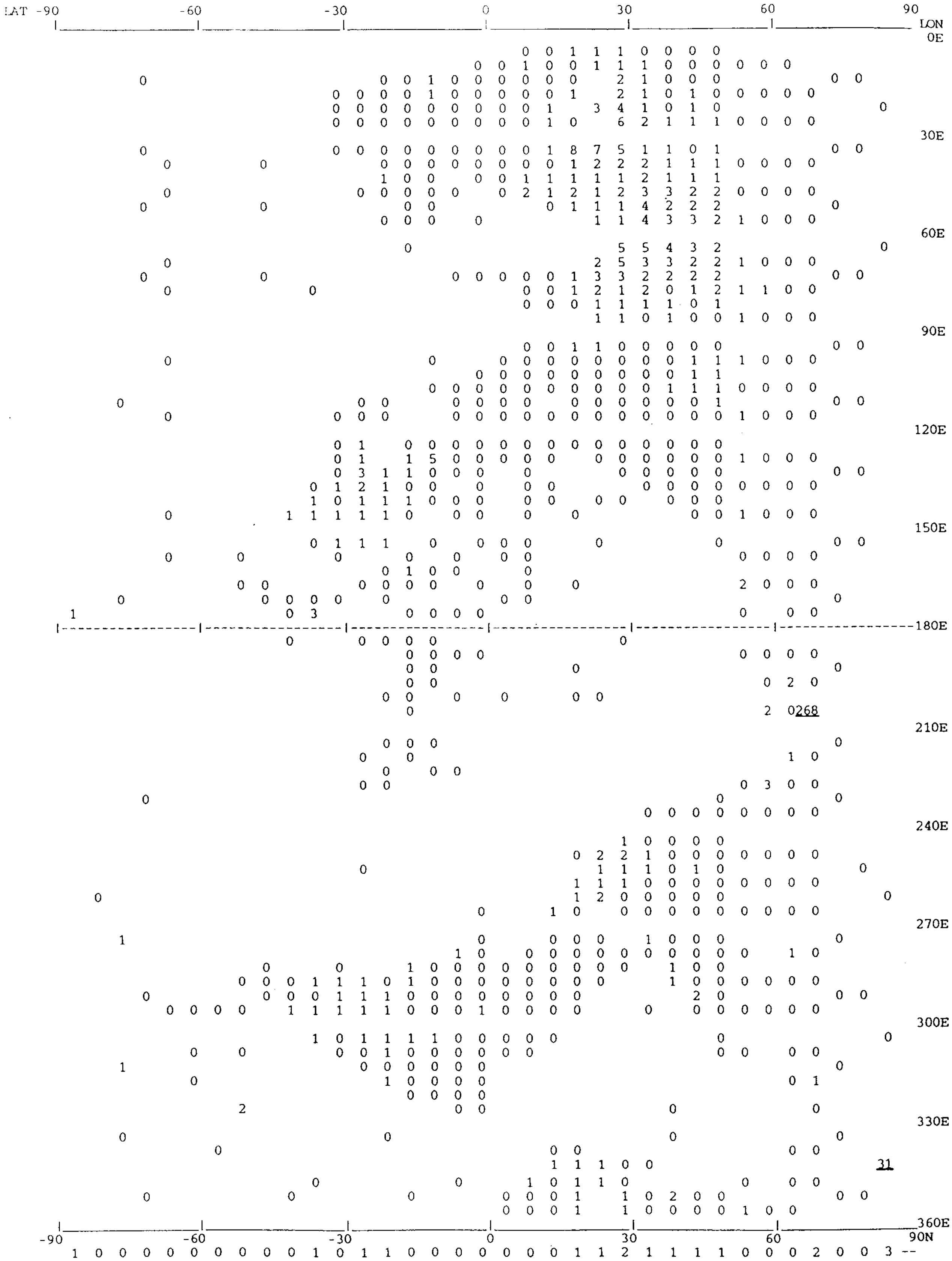

Figure 5a. Global distribution of the clear-sky adjustment factor (AF0) in light reports for 1982-1991 land data. Global average for 843 5c-grid boxes with 50 or more reports is 1.007. Values mapped are 100x(AF0-1) where AF0=1/(1-fb*f0).

LAT -90 · -60 · -30 · 0 · 30 · 60 · 90 (LAT ticks printed along the top axis)

LON																																				
0E									0	0	0	0	0	0	0	0	0	0	1	1						3	3	3								
					0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1						2	2		5	1	0	0				
									0	0	0	0	1	2	1	1	1	0				3			5	3	3	2					0	0		
					0	0	0	0	0	0	1	2	6												4	4	19		10	6	27	0				
									0	0	1	1													4	14	8								0	
					0	0	0	0	0	0	0	1													4	12	3	4		5	36	60				
30E									0	0	0	1	1	1	1									11	3	6	3	2					0	0		
					0	0	0	0	0	0	0	0	1	1	1		0	0				7	9	10	1	5	4	2			1	0				
									0	0	0	0	0	1	1	1	0	1	1		5	7	6				2									
					0	0	0	0	0	1	0	0	1	0	1	1	0	0	1	2	4			22	2						2	0				
									0	0	0	0	0	0	0	0	0	0	0	2	4	3	8	12									0	0		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	8	10								0				
60E									0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	6											0	
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	3								2				
									0	0	0	0	0	0	0	0	0	0	0	1	1	3	5										1	0		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1										2				
									0	0	0	0	0	0	0	0	0	0	0	0	1	1														
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2													
90E									0	0	0	0	0	0	0	0	0	0	0	0	1	1	2										1	1		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3														
									0	0	0	0	0	0	0	0	0	0	0	0	0														0	
					1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1													
									0	0	0	1	2	4	2	0	1	0	0	0	0	0	0										1	1		
					2	1	0	0	0	0	0	1		11	6	1	0	0	0	0	0	0	1	0	3	3										
120E									0	0	0	1			13	2	1	0	0	0	0	0	0	1	1	2	2									
					3	0	0	0	0	0	0	1				5	1	0	0	0	0	0	0	0	1	2	5									
									0	0	0	2				6	0	0	0	0	0	0	0	0	1	3	4						1	1		
					0	0	0	0	0	0	1	3			3	1	0	0	0	0	0	0	0	0	1	2	3	3	1	1						
									0	1	1				1	1	1	0	0	0	0	0	0	0	0	1	2	2							1	
					0	0	0	0	0	1	5			3	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0						
150E									0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0					1	0		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0					
									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1				
			0	0					0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					1	0		
					0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
180E									0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0	
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
			0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	0		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1					
210E			0	1					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	0		
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0				
									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0	
					0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		4				
				0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1					0	0		
					0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	2	1	1			13				
240E									0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2											
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2							0				
				0					0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	3									1	0		
					0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1										0				
									0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	1											2	
					0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1						4	7	0				
270E									0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	2								0	0		
					0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	3		144	110	2	3	1	1				
									0	0	0	0	0	0	0	1	1		0	1	0	0	0	0	2	3	49									
					0	0	0	0	0	0	2	2	0	0	1						1	0	0	0	0	2	5	41	5	6	1	1				
				0					1	2											0	0	0	0	0	1	6	19					1	1		
					0	0	0	0	1	1	2									0	0	0	0	0	0	0	3	10	20	1	0	1				
300E									1	2	1	1								0	0	0	0	0	0	0	0	5							5	
						0	0	0	0	1	2	1							0	0	0	0	0	0	0	0	1	1	2	1	3	6				
			0						0	1	0	1	1	1				0	0	0	0	0	0	0	0	0	1	0					2	4		
					0	0	0	0	0	0	0	0	1	1				1	0	0	0	0	0	0	0	0	0	0	0	1	3					
									0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0								
					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2				
330E			0	0					0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	0					1	0		
					0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3	2	1	1	0	0	0	0	0	0	0	1				
									0	0	0	0	0	1	0	0	0	0	0	3	5	7	8	2	0	0	0	0							1	
					0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	2	4			2	1	1	1	0	0	0	1	1				
				0					0	2	0	0	0	0	0	0	0	0	1	1				4	3	3	2	1					0	0		
					0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1						3	2	1	2	1	1	0				
360E																																				
90N	--	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	0

-90 · -60 · -30 · 0 · 30 · 60 · 90N (LAT ticks printed along the bottom axis)

Figure 5b. Global distribution of the clear-sky adjustment factor (AF0) in light reports for 1982-1991 ship data. Global average for 1487 5c-grid boxes with 50 or more reports is 1.003. Values mapped are 100x(AF0-1) where AF0=1/(1-fb*f0).

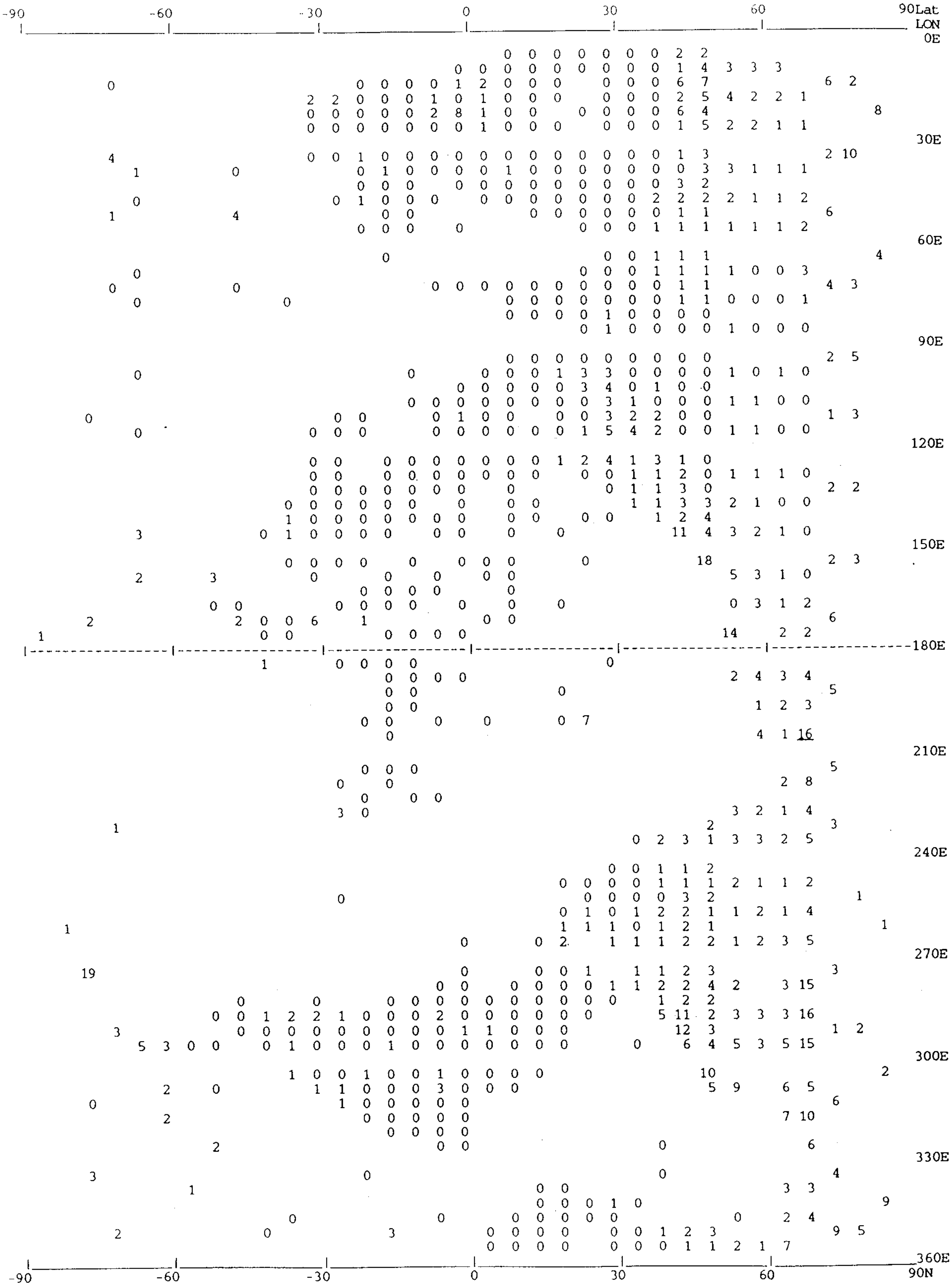

Figure 6a. Global distribution of occurrence of N=9 (f9,%) in light type reports for 1982-1991 land data. Average of 843 5c-grid boxes with 25 or more reports is 1.1%.

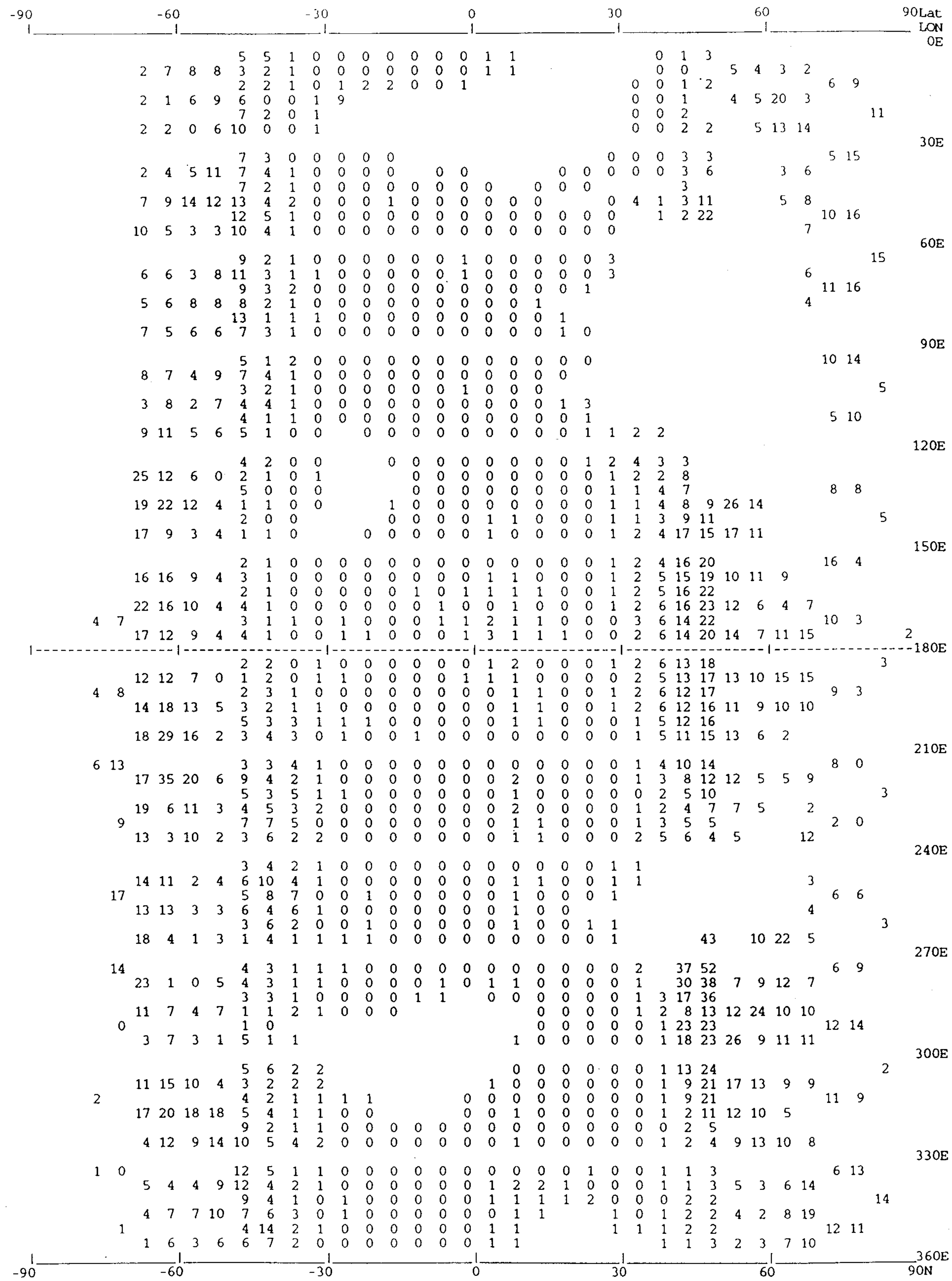

Figure 6b. Global distribution of occurrence of N=9 (f9,%) in light type reports for 1982-1991 ship data. Average of 1501 5c-grid boxes with 25 or more reports is 3.3%.

Appendix A. Percent Frequency of Occurrence of Extended Code Values for Cloud Variables in Edited Cloud Reports (Light). Also: percent that reported code occurs with precipitation and percent of total precipitation that occurs with each code value. (rpts=reports)

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	0.0	15.3	6.9	7.6	5.9	4.3	6.0	10.1	18.3	24.1	1.5
% with ppt	0.0	0.0	0.7	0.2	0.3	0.5	1.0	2.4	8.0	34.3	28.8
% of ppt	0.0	0.0	0.1	0.1	0.2	0.2	0.6	2.4	14.0	78.4	4.1
SHIP											
% of rpts	0.0	5.8	5.0	7.6	9.0	8.0	7.4	11.8	14.0	28.0	3.5
% with ppt	0.0	0.0	0.3	0.2	0.5	1.1	2.0	3.7	7.0	22.6	26.7
% of ppt	0.0	0.0	0.2	0.2	0.5	1.0	1.7	4.9	10.9	70.3	10.4

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	2.6	25.6	11.2	10.9	7.9	5.7	5.8	6.7	8.9	14.6	0.0
% with ppt	11.7	0.5	1.1	2.9	5.3	8.7	12.3	16.0	16.1	37.8	0.0
% of ppt	2.9	1.2	1.2	3.0	4.0	4.7	6.8	10.3	13.7	52.3	0.0
SHIP											
% of rpts	15.3	8.5	6.4	9.8	9.4	7.9	6.4	7.8	7.8	20.7	0.0
% with ppt	9.0	0.1	0.6	1.1	2.1	3.9	6.0	8.8	10.0	24.6	0.0
% of ppt	15.3	0.1	0.4	1.2	2.2	3.5	4.3	7.6	8.6	56.8	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	19.8	1.7	0.5	1.9	3.1	13.3	23.0	10.6	3.4	1.6	21.1
% with ppt	3.4	28.6	38.0	42.3	39.3	23.1	9.6	5.8	5.8	8.2	4.3
% of ppt	6.4	4.7	2.0	7.8	11.5	29.2	20.9	5.8	1.9	1.2	8.7
SHIP											
% of rpts	22.5	4.1	1.1	4.0	12.2	24.3	18.6	5.8	2.2	2.0	3.1
% with ppt	6.7	25.6	29.6	27.6	16.8	7.7	4.0	2.8	2.3	1.8	1.1
% of ppt	16.9	11.6	3.8	12.5	22.9	21.0	8.3	1.8	0.6	0.4	0.4

LOW CLOUD TYPE

			Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fg
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
LAND													
% of rpts	2.6	38.3	6.3	10.2	2.4	2.2	15.5	4.0	3.8	5.9	6.6	0.1	1.1
% with ppt	11.7	4.7	0.8	4.0	18.3	5.2	11.7	14.4	67.2	8.7	28.6	100	0.0
% of ppt	2.9	17.1	0.5	3.9	4.2	1.1	17.2	5.5	24.3	4.9	17.8	0.5	0.0
SHIP													
% of rpts	15.3	13.3	11.4	13.5	5.4	6.0	10.8	5.9	6.6	6.5	2.6	0.1	2.6
% with ppt	9.0	6.8	0.7	2.4	9.2	3.3	7.7	22.3	34.5	7.2	21.9	100	0.0
% of ppt	15.3	10.1	0.9	3.7	5.6	2.2	9.3	14.6	25.3	5.2	6.4	1.4	0.0

MIDDLE CLOUD TYPE

			As	As	Ac	Ac	Ac	Ac	As	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
LAND														
% of rpts	17.6	45.9	1.4	2.6	10.8	4.4	1.6	1.5	7.1	1.0	0.1	2.6	0.7	2.8
% with ppt	15.0	1.0	17.7	7.4	2.6	2.0	3.8	7.3	4.6	2.2	9.2	100	100	100
% of ppt	25.0	4.6	2.4	1.8	2.6	0.8	0.6	1.0	3.1	0.2	0.1	24.5	6.9	26.4
SHIP														
% of rpts	36.1	26.8	3.5	4.6	5.1	3.8	2.9	4.9	4.8	2.0	1.4	2.8	0.2	1.2
% with ppt	9.4	0.9	3.9	3.5	2.2	2.4	2.9	6.4	3.0	3.1	7.6	100	100	100
% of ppt	37.5	2.7	1.5	1.8	1.2	1.0	1.0	3.5	1.6	0.7	1.2	31.2	2.4	12.8

HIGH CLOUD TYPE

			Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	33.2	36.3	11.5	10.5	0.9	0.8	0.8	1.8	1.9	1.9	0.4
% with ppt	28.4	1.0	1.3	1.7	6.2	0.8	1.5	2.4	11.3	2.4	1.9
% of ppt	89.6	3.6	1.4	1.7	0.5	0.1	0.1	0.4	2.1	0.4	0.1
SHIP											
% of rpts	50.9	28.8	5.7	3.2	1.2	2.1	1.5	1.5	1.1	2.4	1.5
% with ppt	15.9	1.4	2.4	2.5	4.4	1.7	1.4	2.4	3.8	2.5	2.5
% of ppt	90.1	4.4	1.5	0.9	0.6	0.4	0.2	0.4	0.5	0.7	0.4

Appendix B. Glossary of Terms and Abbreviations Used*

Term	*Meaning and description*
5c grid	5×5^{o} (latitude x longitude) boxes between latitudes 50N and 50S, 5x10 for latitudes 50-70, 5x20 for latitudes 70-80, 5x40 for latitudes 80-85, and 5x360 for 85-90.
actual amount	Fraction of the sky covered by a cloud, visible or not.
all reports	All reports regardless of whether they are light or dark.
awp	Amount-when-present. The average fraction of the sky covered by a cloud type when it is present, whether it is visible or not.
dark reports	Reports for which illuminance criterion is not met (IB=0).
ECR	Edited Cloud Report. Synoptic cloud reports screened and edited for cloud code consistencies and written as the 56-character report described in Table 9.
ECRA	Archive made up of edited cloud reports.
extended code	The synoptic code extended beyond the usually allowed values of 0-9 to allow C_L=10 to represent Cb, C_L=11 to represent fog and C_M=10,11,12 to represent Ns cloud.
f	Frequency of occurrence. For a cloud type it is the fraction of weather observations in which the cloud type is present, whether it can be seen or not.
light reports	Reports for which illuminance criterion is met (IB=1).
NOL	Non-overlapped; refers to method for determining upper level cloud amounts.
ROL	Random overlap; refers to method for determining upper level cloud amounts.
total reports	Reports suitable for total cloud analyses (and clear sky, fog, and precipitation); either all reports (the entire ECR data set) or light reports only.
type reports	Reports in which cloud type information is given ($Nh \geq 0$ and $CL \geq 0$. These may be light, dark, or all reports.

* Terms not shown here may be defined in Table 1, 2, 4 or 9.